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Systematic approaches to the presentation of academic studies

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SYSTEMATIC APPROACHES TO THE PRESENTATION OF ACADEMIC STUDIES

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ABSTRACT

The basic purpose of this Dissertation is to help to fill the gap experienced by many students between secondary and tertiary education; a gap which arises from the failure of students to understand the need for the use of the critical conceptual skills and systems analysis. These have enabled *Homo sapiens sapiens (Hss)* to use his experience of his environment to apply his understanding to the solution of problems presented by that environment; phylogenetically speaking, it has taken short period for *Hss* to become the dominant species.

This involves, first, the consideration of historical studies of the intellectual and linguistic means that evolved to meet these needs; complex problems always involve complex systems. Secondly, there is a consideration of the progressive development of those skills by institutionalised education and *Hss*'s outstanding intellectual mastery of his environment and the use of systems analysis and conceptual thinking. This is followed by an attempt, by tracing the development of those skills to show how they may be acquired and developed by the appropriate training and discipline of the vast complexity neurological systems of the human brain, especially in the use of language, that have evolved to deal with those problems involved in securing the survival of *Hss*. Thus the tertiary student needs to be introduced to the complexities of the infinite variety of systems, the analysis of which forms the basis of the subject matter of the tertiary student's studies.

An argument for the need for systematic approaches to modern academic studies is introduced. The increasing importance for the modern student of an awareness of the developments in systems study and conceptual analysis is emphasised. Some limited idea of the significance of such an approach, may be of value, illustrated by detailed historical examples. The thesis of this study is that students and their teachers from the outset of their tertiary education should be made

specifically aware of this historical background, especially through study of the actual contribution of scientists. Hence the emphasis on the development of systems analysis and conceptual thinking that began with Galileo and Isaac Newton, and was followed later by Einstein and others. Striking developments in academic thinking have developed with the computer age, all of which must be seen in the perspective of the development of language and thinking skills generally, in the axiomatic deductive thinking of Euclid, the systems analysis of Ross Ashby, Wiener and Beer, and the practical studies of academic thinking as exemplified in the Thomas Kuhn's book on the methods of scientists. Stimulated by these, teachers can arouse the interest and enthusiasm of students to cultivate the thinking systems of their own brains and minds, rather than use a purely epistemological approach.

It is suggested that such knowledge and its application should eventually be imparted in structured courses, with explanations and exercises in the presentation of the results of academic studies of typical problems in the form of essays, assessments and examinations. Thus students can become familiar with the structure of modern academic thinking and aware of the methods of systems analysis.

This thesis contains no material which has been accepted for the award of any degree or diploma in any University, and to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text in the thesis.

Nigel Cox

PREFACE

This Dissertation is intended to be of practical value to university teachers and their students who, in the course of transition from secondary to tertiary studies, may find themselves disadvantaged by failure to understand what is required of them, and may require special help. This may partly be due to lack of confidence in their experience of secondary education and partly from misguided ideas about their own potential. This aspect is considered subordinate to the major part of the Thesis, but is nevertheless included, since the writer's experience suggests that for reasons discussed in the text, many students do in fact suffer unnecessarily on this account.

The main purpose of this Thesis is to direct the attention of those responsible for the learning development of less mature university students to certain basic principles of modern academic thought, method and presentation. An attempt is made to justify these principles as generally consistent with what might be called modern philosophy of science[1], derived in turn from academic thinking and teaching in universities in western Europe and the United States largely developed during the period 1750 to 1950, a period of great significance in the history of mankind and the growth of knowledge. While its effects are embedded in modern education, there is ample evidence that its significance, for various reasons, is not made specific in primary and secondary education, with the result that many students, especially in their first year, fail to realise the standard expected of them. They may assume that tertiary education is just a continuation of the primary and secondary education to which they have become accustomed, and as a result they fail to understand the specific systematic approaches to explanation that characterise academic education.

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[1]The approach of the writer is interdisciplinary: History , History of Science, Philosophy of Science, Education. It is acknowledged that the views of some concepts in Psychology and certain aspects of Research Methodology are not the only defensible views on such matters.

It is assumed that in most universities there are such deficits in the education of undergraduates. It is however felt that this not an unreasonable assumption for many university teachers, especially those with the responsibility of providing learning development[1]. Not all of them are familiar with the historical background, and in any event, what evidence is drawn from the perspective of academic history should do something to substantiate the views expressed.

Accordingly an attempt is made to explain and describe the origin, development and characteristics of modern academic thought itself, as far as is relevant, by describing the lacunae, in the hope that this material will commend itself to those responsible for the kind of learning-development activities that some modern universities provide. It is therefore intended that the study should offer something rather more to the point than advice on examination skills and essay-writing technique, but rather what will favour a constructive and thorough understanding of modern academic thought and expression. It may be that by no means all those who try to help students in these ways are aware of precisely what specific academic skills are required to fill the gap. Many who teach at universities are well aware of the great contribution in method and theory and research that in the last few hundred years have contributed to their own specialisations, but they may be less aware of the general application of certain methods to the approach to nearly all academic studies University teachers are less aware of the need for critical conceptual and systems analysis and synthesis[2]. Many academic teachers may even be unaware of the failure of modern students to understand the structure of their own personalities and the resources of the human brain, to which some attention is given in the earlier part of the study. Many university teachers are well aware that a capacity for self-discipline in matter of regular habits of study is essential, but they are also aware that homilies on the subject are not particularly effective - hence the section on the brain and the Self. A critic may well question its

[1]See Tinto (1975) Dropouts from higher education *Review of Educational Research,45*, 89-125. See also Hall & Harper (1981) Student discontinuance;university or student related? *Australian Educational Researcher, 8*, 4, 22-31.

[2] See glossary

relevance, but I have been particularly anxious to develop a thesis that will be of practical value as well as of academic interest. Hence, in part, the exercises and examples included as Appendices, which it is hoped will also help to clarify and simplify textual explanations.

There have been other problems. To meet the requirements of an academic dissertation for a doctorate, supervised within a Faculty of Education, something more is required than a purely critical and theoretical and historical account of academic thought and methods derived from the history of the philosophy of science over a period. On the other hand, a baldly practical handbook and guide to young students on answering questions and writing assessments, however welcome to students, is barely satisfactory as a Dissertation. The compromise has been to make every effort to establish the essential points being made by providing adequate instantiation, even if at the risk of apparent superfluity. Further, the material presented is directed primarily at the university teacher, not the student, and it is hoped such apparent 'padding' may provide teaching material (even if from other disciplines) of value in the classroom. In this connection, it is felt that although General Systems Theory may have disappointed the cybernetician and the psychologists, it is hoped that the attention given to Critical Conceptual Analysis and to what might be called elementary systematics will prove of value to the young academic student.

INTRODUCTION TO PART I
THE EDUCATION OF THE MIND

The intention of these opening Chapters is to explain what students need to know of the educational function of a university[1], of what the university will try to do for the student in a day-to-day sense, and what in its turn it will expect from students in their own interests. This expectation arises because academic learning at a university requires levels of thinking, analysis and presentation best obtained by special training and practice. To experience this kind of education in the perspective of the development of the student's whole personality almost from the cradle to the grave, students need to understand that what their primary and secondary education has so far given them is, as it were, a minimum survival equipment. At primary and secondary schools, what has been imparted often represents the discharge of an obligation ordained by law for the student to receive, and by civilised societies to deliver. The content and objectives of such secondary education seem usually to prepare students for some unspecified further education, rather than specific preparation for tertiary academic education[2].

Those students who ultimately find themselves admitted to a university are so admitted, not necessarily because they are regarded as having been carefully prepared to take full advantage of all that such an academic opportunity offers, but because of the outcome of various pressures and decisions. There are, for example, those who perceive the university as the opportunity for professional studies and a stable socio-economic future: their presence is often the result of parental and social pressures; there are those, perhaps less mature, for whom the university campus life alone has its attraction, and for whom academic study is incidental. Again, there

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[1] Newman (1976) *The Idea of a University*. A book which is inspiring but somewhat idealistic; many concepts are unanalysed.
[2] McGaw (1996) *Their future: options for reform of the Higher School Certificate.*

is a somewhat amorphous indeterminate group, who are often at a loss to account for their presence on the campus, or why they have chosen the subjects they have elected to study, except in vague terms of peer perception of future graduate employment. The result is that sometimes this large group tends in fact to be academically uncommitted, and for trivial reasons changes course, or abandons academic studies altogether, and 'drops out'. Most modern universities are increasingly aware that, in the interests of efficient management and avoidance of academic wastage, it is important that this group should be identified, and special qualified provision made for them[1].

The particular aspects that are the concern of this study do not however relate to the socio-economic and political factors that are determinants of student attitudes, but rather to the more profound academic shortcomings in institutional education that may impair the student's understanding of the structure and purpose of academic learning. University students are perceived by those responsible for their admission to have sufficiently profited by their earlier education to justify further educational opportunity; they have the opportunity to develop an independent mind, capable of a sufficient mastery of what is considered knowledge, so as to be able eventually to put it to use for their own and for the general good. To achieve this, students might profit from knowing sufficient of the human brain to develop their own personalities, the individual Self, and from knowing sufficient of the mechanism of their own brains (on which so much depends) to have confidence in the almost unlimited possibilities that lie before them.

These opening chapters therefore attempt to describe, discuss and convince the student with evidence of, the very complex structure of the human brain, and of its immense potential for excellence. This kind of information and the evidence to confirm it, it is not likely to have formed part of his or her previous education.

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[1] Tinto (1975) Dropouts from higher education *Review of Educational Research, 45,* 89-125. Tinto finds that drop-outs tend to be those who feel socially isolated.
Hall & Harper (1981) Student discontinuance; university or student related? *Australian Educational Researcher, 3,* 4, pp.22-31. Hall & Harper find that the causes are both university and student related.

Especially important is the relationship of language to thought, and, above all, an understanding of the problems of the inter-relationship of conscious thought to the idea of the disciplined Self. How far the student is aware of the significance of this inter-relationship may determine the student's response to his academic opportunities. It is this degree of awareness that may enable the student to understand and control that Self, along the lines explained in the later chapters of this Part.

CHAPTER I : INTRODUCTION

§ 1: The Objective

The main objective of this study is to explain and explore certain gaps in the education of modern university students, especially in their first year. Few experienced university teachers would deny that, while at least some modern students shew a greater awareness of the requirements of academic studies than others, yet at the other extreme, rather more shew themselves lacking, in varying degrees, such attributes as independence of thought, clarity of expression, imagination and originality. This is of course apart from those students who, due perhaps to inadequate admission procedures, emotional instability, or inadequate secondary education, are unlikely to profit by a university course of study, and can be expected not to last the distance. It is still difficult to resist the impression that there is a persistent failure on the part of many students to make the most of their potential. It is not so much a question of remedial instruction in orderly and logical expression, as perhaps a failure to understand the essential advances in modern thinking that causes intellectual expectations and standards to rise. University teachers themselves are therefore well aware that the best students are capable of very good work indeed, and are capable of rising to the challenges confronting them. Such students, if made aware of what is required, have the potential to deliver it. But the impression persists that there would be more of them, if more of them understood what was wanted. To fill that deficit in the progressive education of the human mind is part of the purpose of this study, and involves systems analysis and critical conceptual analysis (CCA). A concept is defined as a mental schema represented by any term used to explain a system, whether used appropriately or not. Critical conceptual analysis is the decision procedure for the appropriateness of the terms used[1].

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[1] Glossary *Systems Analysis.*

To make clear the origin of the deficit, an attempt will be made in this introductory section to place that development in the perspective of the historical emergence of the human mind, and to do so from the point of view of neuroscience and analytical philosophy, rather than that of a narrowly cognitive-psychological approach.

§ 2: The Historical Background to Language

It seems appropriate to begin with an attempt to set the situation in historical retrospect. There can be little doubt that what distinguishes the species Homo sapiens sapiens (Hss) from all other species is the human brain, and what distinguishes that brain from all other brains, is the use of language for the cultural transmission of knowledge and experience. This language-using brain seems to have introduced an entirely unique feature into our planetary environment. All animal species other than Hss appear to have evolved by a process of phyletic gradualism,[1] which depends on gene mutations which are supposed to adapt the organism to changes in the environment and thus to ensure the survival of the fittest of a species; in the case of Hss the process is very significantly different from that in all other animal species. It seems that fairly early in the evolution of the human species certain changes took place in the cerebral structure of an anthropoid species that were necessary to accommodate the greatly increased neural structures for language, and recent research[2] suggests that the space in the cranium (the *planum temporale*) to be occupied by the speech centre began to develop perhaps as much as 500,000 or more years ago. There is a certain amount of controversy here, but some form of language itself is thought to have emerged about 100,000 years ago,[3] and perhaps arose only once. If so, all human languages may have originated in the eastern part of Africa. Perhaps inconsistent with this hypothesis is the global

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[1] Mayr (1963) *Animal Species and Evolution.*
[2] Le May & Geschwind paper in Caramazza and Zurif, (1978) *Language Acquisition and Language Breakdown*, pp.311-328.
[3] Kandel & Schwartz (1985) *Principles of Neural Science* Ch.52, p.691.

distribution of the species, changing coastlines and the fact that language is universal and unique to the species.

Although language clearly involves some kind of learning, there is now evidence that a substantial component may be innate. Indeed since 1970 there has been formulated the Wernicke-Geschwind hypothesis[1] which prompted new ideas about language. "All human languages are creative, structured, meaningful and interpersonal".[2] The implications of this are of great importance to all university students and their teachers, and must now be considered.

The fact that our natural language is creative, structured, meaningful and interpersonal makes language eminently suitable as an alternative to the genetic transmission of the means of survival, the phyletic gradualism alluded to above, on which all species of animal life, other than Hss, have to depend for their capacity to survive. Of course animals do teach their young various skills, but they cannot use analytical and conceptual language to improve such skills as they teach. In other words, while animal species other than Hss seem to depend for survival mainly on transmitted instinctual behaviour and genetically transmitted mutations, the species Hss is able to depend in addition on natural language and hence on culturally transmitted experience and knowledge. For animals other than man, without a neo-neocortex, such a cultural transmission is impossible[3]. This is a particularly significant point historically, and can hardly be sufficiently stressed in the course of this study .

Most other animal species, though able to communicate with their species, and sometimes with other species by various signals[4] (calls, cries, songs, gestures, colours, scents), do not transmit, describe and analyse experiences of their environment in order to solve problems of survival, but as mentioned above, rely

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1 There is more detailed discussion below, in Chapter X, §8.

2 Kandel & Schwartz (1985) *Principles of Neuroscience* pp.7-17.

3 In Eccles (1991) *Evolution of the Brain*, pp.211-216, there is a detailed discussion of the importance of the neo-neo cortex.

4 See Appendix A,

for survival very largely on the purely genetic transmission of mutations. The animal kingdom, as the Victorian biologists expressed it, relied on instinctive behaviours to survive (building nests, spinning webs) which were transmitted from generation to generation by means of genes, as also were useful physical mutations (claws, beaks and so on). There was an element of chance about this, as it took time for mutations to become genetically established. A sudden cataclysm - a meteorite explosion with clouds of dust bringing about a relatively sudden change in climate - might bring extinction to a cold-blooded species unable to adapt rapidly by mutation.

The species Hss, in such a situation, aided by natural language, could adapt to the change by devising clothing from animal furs, and by transmitting this knowledge by means of language. Of course, genetically transmitted instinctive behaviour still persisted in Hss - fear still warned the child of danger, parents still cared for offspring. The evolution of language must at first have been slow, and it is only in very recent centuries that the means of cultural transmission have rapidly accelerated, to the extent that now the species Hss spends many of his waking hours in consciously thinking in language-terms of his cultural heritage. Of course, language is socially a very convenient device - it is useful, as travellers in areas where their native language is not spoken soon become aware, to be able to seek information and communicate needs, wants and desires. But of course this convenience is insignificant to the species as a whole, relative to the much greater significance of being able to secure the survival of the species by the transmission of knowledge and thought from generation to generation[1].

This even greater advantage of recorded speech became much more marked with the development of written language, which was a later and much more recent development. As mentioned above, the earliest evolution of language was very

[1] The consequences of language deprivation can be catastrophic. In Rymer (1993) *Genie: a scientific tragedy*, there is detailed the catastrophic consequences of language deprivation from infancy to the age of 13.

gradual, and it was relatively late in the process that writing emerged, perhaps at first in ideograms (later hieroglyphs) from which probably evolved alphabetic writing. Linguists tend to be unmindful that it may not have been until this stage was reached, perhaps in Sumeria about 3,500 B.C., that language was recognised as grammatically structured into words, and sentences. From the Sumerians, the alphabet went to the Phoenicians, thence to the Greeks, to the Romans and later to Europe. Of course some human societies remained without writing until relatively recent times.

On the other hand, there are the non-users of natural language as we know it, consisting of all animal species other than Hss. Clearly, these animal species cannot be said to 'think' or transmit knowledge in language terms, in the way Hss does - though it is hardly possible to deny that they are aware of and experience brain-activities and sensations, visual images and so on, and have mechanisms for retrieving these activities from memory systems. Nor can it be denied that they are capable of instinctive (genetically transmitted) behaviour, and presumably can recall images of the effects of such behaviour, and in that sense they can learn. But while there is no evidence that animals are capable of thinking in language terms as does Hss, there is however some evidence that an animal may be conscious of itself in some degree[1].

Natural language, in which the continuity of human experience is usually presented, consists of symbols - that is marks on paper or some other material, sounds, gestures and signs - a symbol being defined as a sign with a conventional referend, such as a thing, or set of things, or set of sets of things, properties, attributes or relations, including mental constructions. It is especially important for students to note that these symbols, also called words or terms, are distinct from that which they conventionally symbolise. There is the symbol on the one hand, and on the other the thing symbolised - each has its separate material existence.[2]

[1] Premack (1975) *Intelligence in Apes and Man.*
[2] Details are given in most textbooks of modern logic; for example Stebbing (1950) *A Modern Introduction to Logic.* Appendix A, pp.499-501. The most important discussion is, of course, Whitehead & Russell's *Principia Mathematica.*

The relation between the two is *semantic* or 'meaning relation'. So that language may be used creatively, meaningfully and interpersonally, words may be combined to form sentences, questions and requests according to certain conventionally recognised rules, called *syntax*. The study of the two together (semantics and syntax) is generally called grammar.

So far we have been considering 'natural' languages, like English and French. But students need to recognise that there may be languages other than those that have naturally evolved, and these 'languages' also represent other activities of human and other brains, and it is of interest at this point to emphasise that using language, and thinking in terms of language, are by no means the only activities of the human brain. In the first place, the human brain clearly employs at least two languages - possibly more. If 'language' is defined as communication by means of symbols, then clearly Morse code is a way of symbolising a language, as also are Chinese or Egyptian characters. Now there can be little doubt that neurones in the brain interconnect, and although relatively little is known of the apparently chemo-electric circuitry and signals by which this activity takes place, it is reasonable to regard these intercommunications as taking place in the equivalent of some kind of language, as just defined. If this is so, then the brain (like a computer) to some extent uses at least two languages. It seems reasonable further to infer that this 'neurone language' is 'non-conscious' but must be 'translated' (up to a point) into natural human language. Introspective evidence as well as neuroscientific research suggests this is so[1]. Hence perhaps the delay we sometimes experience vocalising items (e.g. a proper name) from memory. We may therefore reasonably infer a 'language translation centre' in the brain, possibly in the region of the *planum temporale.*

This possibility in turn suggests that there are still other brain activities. A person recognises a piece of music, and is asked to name it, and does so correctly. Animals may of course hear the sounds of musical instruments and even respond to

[1] Kandel & Schwartz (1991) *Principles of Neural Science*, Ch.1, passim.

such stimului, as they may learn to respond to other noises. But surely no-one would maintain that an animal could learn to analyse or appreciate the polyphonic structure of a Bach fugue, for such appreciation, it is significant to note, involves thinking in concepts. With musically-educated human beings, if music is regarded as a form of sounds composed so as to convey or stimulate feeling (as well it may be), then the 'feeling' is translated into the natural language that identified the piece of music. There are many similar brain activities - the toothache that results in the decision to visit the dentist, for example, as well as some reflex and habitual reactions, and even some instinctive behaviour-patterns. It is above all necessary at this point to emphasise that human beings may develop and systematise a natural language for special purposes, as in mathematics, in mathematical logic, and in English for academic purposes, which may differ in syntax and semantics from the natural language on which the academic language may be based. In a like fashion languages for various computational and other purposes may be devised, like BASIC, COBOL, and various computational program languages, each perhaps having its own rules. Obviously all this has significant implications for academic students.

It is however more directly relevant to this study to consider the special activity of thinking with language as a conscious activity of the brain, because of its direct bearing on some of the problems of academic thinking. The environment in which the species Hss has to try to live and survive is highly complex, and language, essential as it is, itself introduces problems - problems of thought and the use of language, that deserve some consideration at this point.

The books we give to young children learning to read are generally written in very simple natural languages, but the physical world is not in fact a world of simple entities, but a complex world of systems and interacting elements, where things are not always what they seem. The objective physical world thus needs to be understood in terms of dimensions and quantities, for it is a world not merely of things and physical sensations. The capacity of the species Hss no doubt gradually evolved some kind way of using sounds as a simple way of coding the physical world, that was perhaps more useful than the simple cries, calls and gestures used by certain mammals for communicating simple needs and wants[1].

But it was not adequate for the real world, which was also dynamic, a world in which things moved and events changed appearances, and the struggle for survival could be difficult. It was in short a world of systems. Both the brain and language had to evolve to keep pace with this complex world, and it seems that about the time of the later ice ages, about 20,000 years ago[2], language had sufficiently evolved to be capable of transmitting a primitive tool-making culture. This ensured a means of survival of very great significance which was to prove much more effective than could be achieved by the survival-of-the-fittest principle implied by neo-Darwinian theory of genetic transmission of survival skills by mutation. Instead, language seems to have become ever more developed to not only represent the complexities of the highly complex physical world, but also for understanding and transmitting human experience of the world in spoken myths and legends.

§ 3: Language and Analytical Thinking

A brief outline of the development of language from proto-languages to the beginning of modern times (say, 1750) is relevant here. The point here is that students may find it helpful to recognise the immense advance in the cultural transmission of knowledge by means of language that came with the invention of writing. The earliest surviving writing was found in Sumeria, and later Babylon. Here Breasted[3] is probably the best authority, and the form was the cuneiform script, and the period about 3,000 B.C.

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1 For a detailed discussion, Eccles (1989) *Evolution of the Brain*, Chapter 4, Linguistic communication in hominid evolution, pp.71-96.

2 Such figures are necessarily speculative, but are often given in such sources as encyclopaedias, for example, (1980) *McGraw Hill Concise Encyclopedia of Science and Technology* under Glacial Epoch, or (1979) *Times Atlas of World History*, pp. 27 & 36.

3 Breasted (1961) *Ancient Times*, p.2.

However, from crude proto-language to the use of marks for numbers, to the beginning of written language, the development seems to have been very slow indeed. Chronological periods before the present are apt to be highly controversial, but it is surmised that the first recognisable human beings were Neanderthals (who probably had language, judging from fossil remains).They existed in Europe about 70,000 B.C. The last remains of glacial sheets melted about 10,000 years ago. All languages now surviving are quite highly developed, but with the use of numbers came concepts and crude ideas of systems to be explained, not just objects to be observed. Speech began perhaps 500,000 years ago as little more than animal communication. How long before that period crude spoken proto-languages evolved is impossible to say.

It seems then reasonable to suppose that for a comparatively long period Hss communicated in spoken (but unwritten) sounds and gestures of various kinds, as do many other species. These communications may at first have symbolised only mental or emotional states, and it may only have been towards the time of the beginning of writing that single words began as symbols to specify particular entities, such as a wavy line for water, and a stick-like little picture for a man. It seems reasonable to suppose that language as we know it really began to develop only with the invention of writing. But such a crude system could not long serve to describe the real world of highly complex systems that Hss had to deal with if he were to survive. It was a world not only of things, but systems of elements relating to and interacting with other elements in the same or other systems. So the necessity must have arisen for words that would take into account this reality of life, and it is thus not surprising to find such problems discussed in writing by the most ancient Greek philosophers like Thales, Anaximander and Anaximenes[1], while problems of real life were discussed in the great stories, poems and dramas of the Greeks like Homer and Sophocles. What was needed was

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[1] Burnet (1908) *Early Greek Philosophers.*

a system of language that would make it possible to discuss not only things but attributes and relations and hence systems of things. So it is perhaps less surprising to find among the archaeologically oldest writing, symbols (words) representing attributes of things, especially in the form of numbers - a new form of language. These written words, representing not single entities, but classes of things, and even classes of classes of things, may thus have evolved. Such words, representing classes of classes of things - ideas like thousand, circle, justice, friendship - proved difficult (and still do prove difficult) and were the subject of a great deal of discussion and explanation (and still are). With these discussions began the first schools to be concerned with languages and thinking. One of the very first was perhaps the one that met over 2,000 years ago in the groves of Academe near ancient Athens. The problems investigated were those later associated with philosophy, logic and mathematics.

Unhappily for the species Hss, this promising phase in the development of the thinking mind lasted only a few centuries, until the decline of Hellenism and the Greek and Roman Empires, and alien immigrations retarded that development until the invention of printing from movable type and the discovery of paper brought the advent of the printed book.

§ 4: Modern Education

Discovery is the fruit of free and independent critical thought, clearly and convincingly expressed. This is a skill that generally seems to need more than a primary- or secondary-school standard of literacy and numeracy - it requires command at least of academic language, including some mathematics and logic. Thus the advent of the printed book did not immediately make possible that interaction between the 'three Worlds' described later[1]. Such an advance was apt to take more than a generation, for the reason suggested above. In the absence of schools, the educational burden on the Hss parents who were themselves barely

[1] Introduction to Part II.

literate was a heavy one, and it was to be expected that the experience of the benefits of education over at least a generation would be needed before both child and parent could assume the burden of acquiring the necessary skills and standards. It is illuminating in this connection to consider the intellectual background of those whom we might regard as the first modern thinkers - like Galileo, Kepler, Newton, Pascal, Leibnitz, Descartes. As we shall later see (Chapter IV; §§ 1, 2, 3) they were not born to wealth and culture, leisure and ease - nor on the other hand, did they experience a childhood of extreme poverty and need. This observation of course is not intended to apply to like modern circumstances, but is intended to account in part for the very significant cultural lag between the invention of the printing-press, and (two centuries later) the great intellectual output of the first half of the eighteenth century, an output which been maintained and accelerated to the present day.

Before concluding this part of the introduction it is important to emphasise that, for the greater part of the million or so years that the various species of Hominoids and Hss have survived on the planet, survival was largely due to the genetically transmitted skills to which most species owe their survival. However in more recent times the species Hss has relied increasingly on the activities of the brain made possible by the use of natural speech and later the written natural language which have enabled the species to transmit culturally all sorts of skills, and also knowledge of our Self and the external world. This intellectual evolution has increased significantly in the last three centuries.

The importance of this last point is not always appreciated by students and their teachers. What it amounts to is that the entire period of the existence of species Hss on this planet, amounts perhaps to about a million years; of that period, only for the last few hundred thousand years has the species been able rely on an accumulated linguistic tradition of culturally as distinct from genetically transmitted knowledge. That is, the organ called the brain has changed from the elemental form found, say, in the precursor of an insect to that found in the brain of an Einstein. Thus, relative to the life of man on earth, we are as yet barely out of our infancy in the perspective of our knowledge and understanding of the external world. As Bertrand Russell has remarked[1], "we know so little, but the marvel is that the little we know has given us such power".

§ 5: The Period 1750 - 1950

It was the Greeks, the innovators of education, who seem first to have recognised man as the "measure of all things"[2] and perhaps Sophocles[3] who expressed the recognition in poetic words "wonders are many, but none more so than man." This capacity for conscious thought implies that, although many species have brains, only man has the capacity, by means of the skilled and appropriate use of languages (especially of written languages of mathematics and other appropriate conceptual languages), to cultivate what might be called a mind, as a means of understanding himself intellectually and the systems of the external world. It is the purpose of what follows to indicate, from a study of certain significant discoveries in the period 1750 - 1950, some ways in which these ends may be served. It is of course the main objective of academic education to train and develop this very capacity so to think with that specially trained Mind.

The need for education in the use of language, when printed books became more freely available in the 16th century, was and remains very great. It took time, because the mere availability of books did not mean that they were read, or that the implications of what was read was understood. It was only slowly realised that some events in nature, like the rising and setting of the sun, and the annual inundations of the Nile, and the fall earthwards of a stone when released, occurred

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1 Russell (1969) *ABC of Relativity*, last page.
2 Plato (1980) *Theaetatus.*
3 Sophocles (1963) *Antigone*, line 332.

with predictable regularity. But to explain and account for these events in convincing language proved surprisingly difficult, and required special education in certain skills (and it still does). It is easy enough to recognise the Moon when you see it, but it is not so easy to understand the concept of the Moon as a satellite of the planet Earth in a solar, mathematically computable system. In fact the need for education in the reading, writing and use of language raises many problems. Such education is a more difficult matter than is commonly supposed.

The reason for these problems derives from the fact that education in the use of language in an academic sense is needed, for the language used is the language of defined ideas - the language of critical conceptual analysis. This above all needs to be carefully explained to students, for it is by no means obvious to them. A child soon recognises that it is a member of a family, but it is longer before the individual becomes aware of the conceptual and logical relations of terms, just as no doubt it took many centuries for the human species to develop the same realisation on a cultural scale.

The trouble is that language does not replicate reality, just as music does not replicate the emotions and feelings it stimulates. Words with more complex referends require more analysis. As just mentioned above, the Greeks had begun to realise this need for academic analysis as an activity of the conscious brain, but for historic reasons, perhaps relating to the development of language, for a period of some 15 centuries after the decline of classical learning, general interest in education in this academic sense waned. The growing child's concept even of the implication of the relationships within an extended family was and still is one learned in childhood by all normal children without special education. Yet the need for the more specialised education that resulted in Newton's concept of gravitation expressed in his equation was the outcome of critical conceptual analysis, which was in a sense the product of an academic education.

It is the opportunity to acquire this kind of academic education that is given to the university student. It is part of the purpose of this study to emphasise, not only to students, but also to those responsible for introducing them to this level of education, the need to be more fully aware of the institutional structure and origin of the modern system of education, and its special relation to those for whom it is intended. By the time young men and women are admitted to university, they are adults (or are perceived as adults) and are presumed to be socially mature to the extent that they are aware of the usual standards and obligations of ordinarily acceptable social behaviour, but they are not always in an academic sense mature in their appreciation of the relation of the individual Self to the academic world they are about to enter. It also seems clear, that this lack of awareness is in some degree shared by those university teachers and administrators responsible for introducing them to academic life.

High 'discontinuance' rates in many modern universities probably reflect such academic immaturity, although it is not intended here specifically to establish and analyse causes and effects. What is more relevant to this study is to make available an historical and analytic approach to the needs of academic teachers and their students. Otherwise a certain deficit may persist in the academic education of students. For example, many lecturers are well aware that their first-year students seem unaware of the higher standards of literary expression required of them. It is not just a low standard of literacy reflected in faulty sentence and paragraph construction, spelling and punctuation - faults that may be remedied by appropriate courses in English - but a failure to use and understand the language of critical and analytical conceptual thinking.

However, before this remedy can be effectively applied, students need to be made confident of the resources within themselves, of the potential of their own brains.

CHAPTER II:
AN ACADEMIC APPROACH TO THE HUMAN BRAIN
- THE SELF

It is surely not unreasonable, and relevant to the purposes of this thesis and to successful teaching generally, to recognise that not all students have equal confidence in their own potential. Some students, it seems hold themselves in low esteem based perhaps on the results of previous intelligence tests and examinations, or perhaps because of overcritical parents. Many however are unaware of the resources of their own brains, and how to use them.

It seems odd that, though students in the course of their education are given a lot of information on a wide variety of matters, most of them are given virtually no information whatever of the structure and workings of the human brain.

Furthermore, this omission possibly leads many students - and their university teachers - to accept without question judgements on the potential of students (for good or ill). Even a modest appreciation of the significance of the little we know of the structure of the human brain would enable an intelligent student to perceive the absurdity of many of these judgements.

Accordingly, the writer has on a number of occasions found that lectures along these lines have evoked inordinate interest, and provoked requests for more! The solid empirical basis of much neuroscientific evidence often proves more convincing than some of the vague theory based on what Wilfred Sellars[1] has called 'folk' psychology.

Finally, it would seem that teachers abdicate much of their responsibility if some attempt is not made to explain the necessity for a regimen of planned and self-

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[1] An article on the subject in Guttenplan (1995) *Companion to the Philosophy of Mind.*, pp.310-315 describes it as the view that many concepts in psychology (like 'motivation') are based on inadequately analysed introspection. For example, Estes (Ed.) (1976) *Approaches to Human Learning and Motivation.* The idea is approved by some and rejected by others.

disciplined study as discussed in this chapter, and the means and mechanisms such as are in the cerebellum to achieve it. What this amounts to is that students (in the light of what follows) should be advised and consulted about their study and specific reading programs, and the discipline necessary for that purpose. If this can be done, most experienced teachers would perhaps be reluctant to place limits on the academic potential of a determined and self-disciplined student, especially when given some understanding of the structure of the mind and brain, especially in relation to the need for the student to be aware of his own SELF.

One of the most curious features of perhaps all human brains, if not of all central nervous systems, is what might be called 'awareness of SELF' - that human beings normally wake up from sleep, or even emerge from a coma, fully aware of their own identity. Attempts continue to be made to create electronic machines called robots or automatons; these are generally designed as systems of electronic circuits intended to perform activities analogous to those of the brain of Hss. Some of these machines are very simple, and (as a result) quite successful. But not even the designers of the most successful would claim that the machine 'knew what it was doing' - that it was 'aware of itself'. At no point does the designer claim that he has introduced a circuit to ensure self-awareness or consciousness. Are animals conscious of a Self? Or is Hss uniquely self-aware? Hss is uniquely self aware in the sense that language enables him to consider and analyse this very awareness in a unique way. The concept of 'consciousness' to Hss of course presents some philosophical and metaphysical difficulties that lie outside the scope of this study, but there are aspects of the Self that are very relevant to the academic student, and it is to these that we must now turn. The treatment here will be somewhat different from a psychological approach, and relys more on neuroscientific research of the brain itself; it willbe suggested that students may profit by being aware that there is a Self which may be disciplined in some sense, by that inner Self to which Popper and Eccles refer in the passages included in the relevant Appendix.

§ 1: The Brain: a Neuroscientific Approach

Early in the 20th Century successful physiological dissections of human brains and bodies led Charles Sherrington (1857-1952) to begin specific studies of reflexes, thus initiating the modern scientific study of the Brain itself as part of the central nervous system (CNS). Almost all studies of the brain had hitherto been of human behaviour, attributing that behaviour to various arbitrarily selected parts of the body, such as the kidneys, the heart, the bile. The science of neurology developed very slowly until the invention of such instruments as the electro-encephalograph and the electron microscope (about 1930). Such studies as did take place were taken very seriously under the ægis of universities like Oxford, Cambridge, London and Harvard. Nevertheless, progress was (significantly) slow (as we shall later see) partly because of failure to understand the need for systematic analysis of the physiological as well as the psychological problems involved.

For reasons already given, students are likely to benefit from appreciating that even now very little is known of the human brain, for when progress began to be made, scientists were, and still are, daunted by its immense complexity, and the sub-microscopic scale of the millions of millions of directly and indirectly connected neurones which largely constitute the human Brain. Hence detailed objective scientific study is relatively recent. Investigation of the human brain began with philosophy, part of which developed into psycho-philosophy and then psychology. For many years it was widely believed that introspective study of the living brain could not be sufficiently objective to be of value. As a consequence, some early twentieth-century psychologists such as Watson and Skinner believed that only the observable behaviour of individuals could be the subject of scientific study. Even so, it was found that purely behavioural studies on the human brain tended to be speculative and unconvincing in the absence of experiment. Subsequently as law and morals prevented experiment on the living human brain, endless experiments were performed on animals. At the same time, it was thought that little could be learned from the dead human brain. It was for long believed that a living human brain was not accessible to observation. But in time circumstances and more advanced methods have changed this.

To shew how changes in scientific and technological procedures have brought and are bringing this about, it may stimulate the interest and confidence of students in their own brains to consider how this progress came to be made; hence it is hoped that this somewhat detailed account will also illustrate the purpose and necessity of certain scientific methods and procedures. Much can be learned from the methods and techniques evolved that may be of value to the modern student.

This illumination came from the surgical treatment of intractable epilepsy and other diseases and lesions of the human brain. In extreme cases epilepsy may make life an almost insupportable burden for its sufferers and those who care for them, for in such cases the patient needs almost constant attention, or he may endanger his own life and even the lives of others. In ancient times, the disease was regarded with superstitious awe, but in time physicians and others became aware that it arose from a physical disorder focused in various patients in different parts of the brain. Indeed the medical profession today is generally agreed that the seizures or fits characteristic of epilepsy are the result of excessive activity in some area of the brain, causing involuntary movement, abnormal behaviour and even unconsciousness. The disease itself is rarely fatal, but it makes life a heavy burden for its victims. Where it is possible to locate the actual area of the disturbance in the brain, after very careful research and experiments with animals, it was decided to attempt brain surgery of the *corpus callosum*, a tract of millions of neurones which connects the two cortical hemispheres and which carries a huge volume of communications. While today certain drugs have been found to alleviate the condition, and even up to a point to cure it, about forty cases were so treated in the 1960s, and this type of surgery is still practised in a somewhat more controlled way. But what it was to reveal in the 1960s was of great consequence not only to the study of the human Brain, but also had implications for the theory of scientific method (this latter argument will be the subject of Part III of this dissertation).

In some cases this tract was completely severed. This surgery did not however completely isolate the two hemispheres from each other, because there are other connecting by-paths through other parts of the brain. Nevertheless, the operation naturally aroused great interest among neuroscientists, psychologists and even philosophers. for there had already been speculation about which of the two hemispheres was the seat of the 'personality'. It was thought that such surgery might experimentally yield evidence about the cerebral localisation of the personality - the Soul perhaps. This was however not achieved.

However surgery of this kind has meant that neuroscientists no longer have to rely solely on experiments with animals. As well, other remarkable and often very expensive means of scanning brain activity have been devised, which will be referred to in due course. Certain psychological tests have also been devised, but psychologists (among them the behaviourists) have long been aware that we cannot always rely on the introspective accounts people give of what they think is going on in their brains. To return however to the studies made on the patients whose hemispheres were wholly or partially divided surgically in the treatment of epilepsy and for other reasons. The surgeons responsible were anxious to check on the results of the operation on their patients' general condition[1]. As far as the immediate purpose of the surgery was concerned, the alleviation of the epileptic condition, the results were generally satisfactory, and other tests at first suggested that the personality and behaviour of patients was (apparently) not affected.

The cases are discussed in Appendix A and deserve thoughtful study, not so much because they solve any particular problem of the brain, but rather because of the insight that they give - especially with regard to the 'conscious Self'. It is a curious fact that a human being, while still an infant, comes to regard himself as identified with a Self. You may go to sleep at night, and apparently lose all

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[1] Popper & Eccles (1977) *The Self and its Brain*, pp.313-333.

consciousness of your external world; but when you wake in the morning, you are at once conscious of who you are, of your problems, your joys, your friends, your whole Self. Even if under general anæsthetic, for example, you still eventually regain consciousness of your Self. Students may be profitably invited to think about this as they consider the following cases. Is this just an illusion? A seminar based on these cases and on Appendix A would be worthwhile, in leading to a better understanding of the Self and the part it should play in the student's studies.

A study of Appendix A should suggest to the intelligent student that the human brain, especially the cerebral cortex or 'roof-brain, is structured in a very interesting way. Most of the brain is hemispherically divided, as Penfield[1] and others realised. Are the hemispheres identical or not? This doubt raised what is known as the problem of the lateralisation of the hemispheres. The search for the elusive 'self' seemed difficult.

§ 2: The Search for the Conscious Self

Most of the brain is hemispherically divided, though the mid-brain and the brain stem are not. The problem is to decide the purpose of this division, for the two parts do not appear to be functionally identical - not like the two kidneys, for example, which seem to represent a kind of 'fail-safe' precaution. The 'split-brain' research we have been discussing represents one way of perhaps resolving the issue as to which functions are allocated (or lateralised) to which hemisphere, though not the only way. Studies of patients who have suffered from cerebral lesions resulting from strokes have also been highly, if not equally, informative. In addition, the injection of sodium amytal into the right or left carotid arterial supplies of blood to the respective hemispheres successively suppresses some activity in that hemisphere (the Wada test), and is used by surgeons as an indicator of the lateralisation of speech. In short, it appears that it is not present possible to localise the Self existentially in any particular space.

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[1] Penfield (1975) *The Mystery of the Mind.*

§ 3: Language: Brain Lateralisation

Dr Patricia Churchland has summed up the lateralisation problem as follows:[1]"The Left Hand (LH) is pre-eminent in the motor control of speech, and generally far outstrips the Right Hand (RH) in comprehension; the RH generally out-performs the LH in manipulo-spatial tasks. Is the LH lateralised for language? It depends on what 'lateralised' means. If it is defined to mean merely that the LH in many brains performs better on verbal tasks than the RH, then indeed language is lateralised to the LH. If it means that the RH has no significant linguistic *capacities* or that the RH contributes nothing to normal linguistic processing, or that the neural tissue in the LH is specialised for linguistic capacities, but the neural tissue of the RH is not, then the claim is still *sub judice*." It is worth adding, from the purely neurophysiological point of view, that the conclusions sometimes made from such alleged lateralisation data should be treated with some circumspection.

It should be emphasised that the position with regard to lateralisation has not changed much at the time of writing (1996-7). The human brain is an immensely complex organ, with its 10^{12} neurones, each one of which has been likened to a mini-computer in function, and the prospect of localising and describing the circuitry of individual cerebral functions is remote indeed. Finally, it should be noted that 'lateralisation', whether LH or RH, in individuals appears to have no necessary relation to 'right/left handedness', 'apart from a purely statistical correlation'. This phrase simply means that some left-handed persons are left-hemisphere persons and some are right-hemisphere persons. It is not known if there is a systematic relationship. To determine the nature of the problem, would initially require some skill of systematics.

The position is that experimental isolation of individual capacities in the brain is (so far) almost impossible to achieve except in a limited, but growing number of particular cases. If for no other reason, it is very unlikely that any such capacity -

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1 Churchland (1986) *Neurophilosophy* p.193.

language, for example - is *completely* isolated to one hemisphere, for there are so many other possible connectivities through parts apparently not so divided - the stem-brain for example. Again, a hemisphere may not respond to language in an experiment - but this may be because that hemisphere cannot activate the organs of speech.

It is hardly relevant at this juncture to discuss the brain itself further, though there remains a good deal more to be said later. Before resuming the chain of reasoning interrupted by this digression, and the three cases that were described, it is relevant to return to the question of the Self. No answer has been given, and in fact some sceptical philosophers deny its material existence, yet, as has already been mentioned, Eccles points out[1], human beings emerge even from deep coma usually conscious of the same Self they have known throughout life. Perhaps there is something to be said for the view of the philosopher John Searle[2], when he suggests that we humans seem to have genetically evolved a conviction that we each have a conscious inner Self. We feel that there is nothing anomalous in affirming that "I am conscious I am conscious." Students generally do believe that they are themselves - though the difficulty is sometimes to accept the consequences of that belief, both for the student and the teacher.

The academic teacher, faced with a class of young adults, needs to recognise that each of these individuals is not equally aware of his or her own potential, or of the consequences of the fact that over the last few years at school, there has developed an inner Self that has to be trained to make decisions that may affect the whole future course their individual lives. In an immediate sense, it is surely the professional responsibility of the academic teacher of first-year students, to ensure that the student is aware of the need to train and discipline that Self to take full advantage of the opportunities offered by the university education to train and discipline that Self to make the best use of its Brain. While few teachers today

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[1] Popper & Eccles (1977) *The Self and its Brain*, pp.370-372.
[2] Searle (1984) *Minds, Brains and Science*, Lecture 6.

would regard themselves as responsible for a student's morals, the academic teacher is surely professionally responsible for making those students aware of their individual responsibility to discipline themselves. An approach to this problem will the subject of the following chapter.

CHAPTER III : THE STUDENT BRAIN AND ITS SELF

In the previous chapter there was some discussion of evidence disclosed during brain surgery for what appear to be the activities of something corresponding to a conscious Self in the human brain. Before considering certain activities of the student's human brain, something further must be said of the introspective awareness of Self familiar to everyone, and which it would seem we share even with animals. A philosopher, John Searle, (as mentioned in the previous chapter) discusses such an awareness of Self in his Reith lectures[1] as a phenomenon in relation to such philosophic problems as the freedom of the Will. However objective philosophers or psychologists may wish to appear, they have to confront the fact there is little chance of persuading those they address that they are *not* conscious of themselves, or that they are *not* responsible for their own actions. As Searle says, "It seems to me I'm conscious I *am* conscious". By this Searle seems to mean that the simple sentence asserting "I am conscious" cannot logically be denied; that there is no way of logically falsifying such a statement. It thus causes no wonder or surprise that surgeons like Penfield tried actually to localise the phenomenon of the Self in the human brain[2]. Although many functions of the brain have been localised in the brain[3], the Self function has not.

This consciousness of self, it therefore seems, is a real property of the brain, since it can cause things to happen, just as experiencing thirst may cause a person to perform the physical act of drinking water. The initial experience of thirst is a mental phenomenon, originating, as far as the brain is concerned, in that part called the hypothalamus, and culminates in the changed mental state resulting from drinking water[4]. It is vital for students, if they are to realise their academic

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[1] Searle (1984) *Minds, Brains and Science*, Lecture 6.
[2] Penfield (1975) *The Mystery of the Mind.*
[3] Kandel & Schwartz (1991) *Principles of Neural Science*, pp.12-15.
[4] Grossman (1987) Motivation, appetitive, biological bases in Adelman (Ed.) *Encyclopedia of Neural Science.*

potential, to have some understanding of the various areas of consciousness specifically associated with their academic activities.

Most teachers would agree that academic success is impossible without awareness of the need for the conscious self-imposed discipline[1] that is its subject. It is, first, important to understand the mechanism and kinds of phenomena that stimulate the various neurophysiological mechanisms involved in academic activities, as it is hoped that the seminar material in Appendix B (concerning the different kinds of 'I') will suggest. Furthermore, of all mental activities, successful study presupposes and relies upon an awareness of the identity of the Self that is performing the activity of studying.

§ 1: Moral Issues

In the climate of opinion on such matters as moral issues during the twentieth century, there have from time to time been various changes in the 'local weather' of opinion, ranging at one extreme from coldly scientific condemnation of any such teaching of morals as nothing more than subjective expression of personal opinion, perhaps motivated by a desire to secure social and political stability by conformity with particular codes of behaviour, and, at the other extreme, blatant advocacy of scientific or economic materialism sometimes in extreme cases applying to whole national state systems. At intervals there have been advocates of particular moral doctrines or traditional religious teachings, sometimes of a very narrowly dogmatic and exclusive kind. To generalise somewhat rashly, as far as university teaching is concerned, around mid-twentieth century attitudes ranged from non-committal indifference on one hand, to advocacy of an irrational conservative morality, on the other.

There is now, at the end of the second millennium, evidence[2] of a movement away from the scepticism of linguistic positivism in some departments of

[1] Self-discipline in the sense of self-imposed goals, rewarded by a modicum of indulgence, provided the goals have been achieved - essentially a Stoic attitude. See Glossary - ***Self-discipline***.
[2] The work and influence of Hospers (1990), Lipman (1980), Splitter (1995) and Wilson (1972).

philosophy, and in the direction that includes a philosophic and logical analysis of ethical and moral teaching. This movement has been accelerated by a widespread awareness of the consequences for the young of addiction to drugs of various kinds and the social instability in family life partly brought about by a high divorce rate, and reflected in many areas by social and economic instability. All this, it seems, has stimulated special attempts to provide objective and academic education in ethics and morals. There are influential schools and teachers of philosophy that are well aware that such teaching has educational advantages to offer as well as obvious social and secular advantages[1]. Morals, in short, are supported by logical and philosophic teaching, as well as religious doctrine. For this reason there exists a widespread movement towards such education, even in primary and secondary schools. As far as this study is concerned this tendency seems to justify the emphasis given to the relevance of consciousness of the Self.

Detailed digression is here inappropriate, but it is relevant to this study that lecturers and students should know a little of its philosophic educational basis, with suggestions as to how it may be presented to students. It begins with the idea of consciousness of the self, the idea of the Self discussed in the previous chapter. What exactly is this 'consciousness'? Philosophers have various ways of explaining this difficult problem[2], like the ways suggested above. But there is one curious thing about it. Even if the philosopher fails in his attempt, there is no chance that the individuals in the audience will lose their consciousness of themselves, and begin to believe that, if they fall into deep sleep, they will not know who they are when they awake (for by 'awake' we mean 'regain consciousness'). From this may emerge the conclusion that we may make decisions, and these decisions may have consequences, which may be described as 'good' or 'bad'. Which is which, and why, may be subjected to rational conceptual analysis. But it is not relevant to pursue

[1] Hospers (1990), Lipman (1980), Splitter (1995), and Wilson (1972), for example.
[2] Searle (1984) *Minds, Brains and Science*, pp.36-41.

the matter any further at this stage, and we must return to the matter of the student and his consciousness of 'I', and its consequences[1]

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It should now be clear that we have reached a critical point in this aspect of the study, one which it is the duty of the teacher to use all the experience and authority he can command to communicate to the student. No successful university teacher would doubt the need for self-discipline where academic success is to be achieved, but students are generally unaware of the above evidence that the brain provides the mechanism for learning all skills, even the skill of learning skills, if proper disciplined procedures are adopted. Likewise, every teacher is aware that no amount of forced concentration and attention produces effective results in the absence of what some call 'self-motivation' - and not any motive will do. Discipline should appear to the student as something reasonable to impose on oneself. Above all, it is what A.C.Aitken (the mathematician celebrated for his extraordinary feats of mental arithmetic) doubtless meant when he said[2]

> Interest is the thing. Interest focuses attention. At first one might have to concentrate, but as soon as possible, one should relax. Very few people do that. Unfortunately it is not taught at school . . . The thing is to learn by heart, not because one has to, but because one loves the thing and is interested in it.

As Aitken must have known, this kind of enthusiasm in immature students is rare indeed. But nevertheless students generally should be aware that it exists, though the reality of course cannot be escaped that for all students ultimately there must be an element of self-discipline. Even though this may not be entirely accepted by certain students, it needs to be emphasised and explained to all students that there is the decision to be faced and made by the correctly identified 'I' of the whole hierarchy. As has been explained, the 'I' of "I wish I studied systematically" is not good enough.

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[1] For an appropriate discussion, see Hospers (1990) *Introduction to Philosophic Analysis*, Chapters 7 and 8.

[2] Quoted in Howe (1991) *Fragments of Genius*, p.156.

§ 2: The Discipline of Academic Study

The first step for the serious student is to accept the need for planned and regular study. Most students recognise the analogy of physical training regimes in sports and athletics, and the need to conform to the ultimate predetermined objective, that is the training alluded to a few paragraphs ago. That is the training alluded to above, which will hereafter be called Taskmaster.

It can be done, and in fact it has been done on a large scale, though under very different circumstances. The writer recalls for example, in England, when peace came after World War II, when there was no further need for a large standing army, in order that older serving soldiers might be speedily returned to civil life, young men over 18 were expected to train for two years in the armed forces. Though there were legal ways of avoiding the rigours of national service, the writer recalls from his own experience that the great majority accepted the discipline, and (as frequent public opinion polls shewed) they 'got used to it' and often confessed "it did me good on the whole". Of course the young conscript was helped by the climate of discipline and the kind of conduct that was then expected. This is not of course to advocate any form of conscription, but at the same time, university teachers might do well to ponder the implications of an atmosphere of systematic self-discipline, that is intrinsic (as opposed to the military discipline which is largely extrinsic). But it is important for each student not to attempt too much - if there is difficulty in maintaining the schedule, the student should not just neglect it, but modify it to something within his potential, however modest. That is, successful systematic self-discipline should also be tinged with realism.

§ 3: Preliminary Training for 'Taskmaster'

Having accepted the need for academic training analogous to athletic training, the serious student (we will suppose he or she is studying for a Business Management degree) decides to get organised to pass the relevant examinations, and an appropriate schedule is drawn up. It will be an excellent opportunity to put theory into academic practice, and that, the student may feel, will do the trick.

To descend to particulars, the student of Business Management will perhaps be familiar with what is known as a Gantt diagram, which is a kind of schedule sometimes used in cybernetics and Operational Research for operations which depend for their success entirely on the cumulative effect of systematic and periodic inputs in order to achieve a desired objective. Such a procedure, the student should recognise, offers the solution to the relevant problem ensuring systematic study. Draw up the Gantt schedule, execute it, and there appears to be no problem - the examination is as good as passed. It is for the tutor to commend this procedure, and advise on the details of the Gantt schedule, and it is for the student to consult the relevant tutor and carefully calculate the period in hours of concentrated study needed over (say) two terms to achieve his objective, and the student will find that very few others are likely to have equalled his effort.

Sometimes, despite good intentions, there is failure for the same kind of reason that many business management methods fail. The failure arises because the schedule has not taken into account certain variable essentials to ensuring that the inputs of concentrated activity were in fact cumulative - for after a few days the daily input of four hours of study may have declined and eventually fallen away to zero. Efforts may have been made a term later to revise and implement a new Gantt schedule (e.g. eight hours a day) with a similar unfortunate result. The reason is of course obvious - the inputs must be sustained.

Much of this chapter has been devoted to discussion of the necessity for systematic and sustained study based on confidence in the brain and the Self. There is of course nothing new in the idea. What is perhaps may be new to students is the neurophysiological evidence discussed, and perhaps the suggestion that university teachers should institutionally reinforce such systematic studies with carefully planned schedules on which to base appropriate Gantt diagrams. These schedules should be planned by teaching staff in consultation with the student. There is need for instruction in critical as well as conceptual analysis. The procedure of critical conceptual analysis (CCA) will form the subject of the next few chapters[1].

Thus the discipline of Taskmaster along the lines suggested above is important for students, especially if taught as a learning skill in conjunction perhaps with Gantt schedules. Some students complain of inability to concentrate. The remedy in such cases may well be self-imposed tasks, or puzzles for example, that require concentrated attention for short fixed periods of time, which are gradually lengthened as ability to concentrate is improved. It is important to interpose short self-imposed rest periods between each task. Clearly, however intellectually gifted a student may be, if he or she cannot maintain the required amount of study, success is unlikely.

Enough has perhaps now been said of the need for systematic and disciplined study, and the responsibility of academic teachers in ensuring that students recognise that realise that the human brain is structured in such a way as to reinforce such disciplined training of the brain. It is relevant now to consider the subject matter to be studied in this systematic way, and the methods appropriate to that end, and the kind of conscious mental activities that are involved.

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[1] See Glossary - *systems analysis*. See also Ch IV.

INTRODUCTION TO PART II

THE THREE WORLDS OF KNOWLEDGE

To all forms of animal life at birth the external world is wholly strange and mysterious. The species Homo sapiens, with the unique capacity for language, and ability thereby to acquire knowledge by experience, and to transmit that knowledge by cultural means, has an inherent means of learning and transmitting more and more. Students at a university find themselves, perhaps for the first time, consciously aware of this situation, and it is thus at this stage appropriate to attempt an analysis of that situation, in a diagrammatic way used by Karl Popper and J.C.Eccles in their book, the *Self and Its Brain*. It is not the only way of considering the situation, and is certainly open to epistemological criticism[1], but university students may find it stimulating if viewed critically.

Consider the following diagram, of three boxed lists, each representing, by the arrows between the interaction of the three indicated 'Worlds' of which the individual human brain is aware.

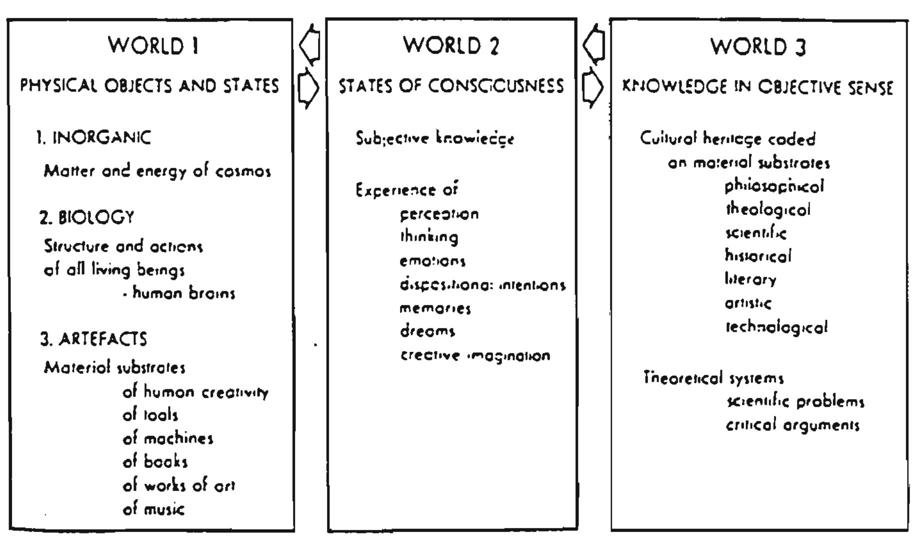

Figure 1. Tabular representation of the three worlds that comprise all existents and all experiences as defined by Popper (Eccles 1970).

With the advantage of speech, and later of the written word and printed books, human beings made very rapid progress, particularly in the two recent centuries

[1] World 3 for example seems to include both true and false 'knowledge'.

(1750-1950), enabling the species Hss to surpass all others in their cultural transmission of knowledge and control of the external world, and, at least in Europeanised countries, it has become increasingly possible for many adolescents eventually to reach a relatively high standard of living by applying that knowledge and skills, acquired by education to the solution of the problems and difficulties of their own lives, and perhaps later the lives of those who depend on them for professional advice.

Many university students will have acquired the basic skills to achieve university entrance at primary and secondary schools, but this process does not occur at a uniform rate, due to the fact that the evolution of natural languages seems to depend on random discoveries and improved means of transmission of knowledge, of which not all students, or all teachers, are uniformly aware. For an example of such an advance, there was the gradual discovery that language could be used to explain systems, which in time led to the understanding of concepts which is so essential to modern students.

The Popper-Eccles diagram above represents all the categories of things that activate the conscious human brain. Remember that each item on each list represents a categories of (1) things that stimulate mental activities in the individual, and (2) the response - the activity itself.

World 1, the first world, consists of all the categories of physical objects and states in the external world that from time to time may stimulate a response in an individual brain. This response is usually in the form of a sensory perception, an activity in the brain itself. It is not the same for each individual. Things may be perceived in different ways by different individuals. The World 1 of the child is not the World 1 of the adult. Appearance and reality are seen differently from one historic age to another[1]. But in a general way, it seems that Hss as a species shares a kind of 'world outlook on reality'. For long centuries, things were largely taken

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[1] Yates (1964) *Giordano Bruno and the Hermetic Tradition.* Far from being a pioneer 'scientist', Bruno is shewn to be more mediaeval than modern; the book provides valuable insight into a different mental world.

for what they seemed to be to everyone - a flat earth, surrounded by a starry firmament, illumined by the Sun by day, and the Moon by night, with daily events determined by human acts, or by propitiating fates or gods or as determined by fates or the erratic motions of the stars. In time, interaction in terms of language between these three Worlds made possible progressive increases in the objective knowledge content of World 3.

World 2, is the World as experienced by the individual brain. Many of these experiences are items stored in that brain's memory, and may be recalled, it is to be hoped, in the examination-room. In the brains of great thinkers, World 2 activities may be thoughts in response to activities stimulated in interaction with both World 1 and World 3, and subsequently emerge in World 2 as subjective knowledge.

World 3 is a store of experience available to all. For example each individual brain interacts with this World 3 of objective knowledge, and for this reason the individual (each in his *subjective* state of consciousness) considers this World 3 and interacts in conscious thought to create from World 3 that individual's own World 2. This World 2 is his own personal world of beliefs, and is the product also of interaction with World 1, the World of physical objects and states (including possibly the content of World 2 states of consciousness of other individuals).

The Three Worlds diagram should be carefully and critically considered by university students. For example, what the academic student calls 'thought' in a subjective sense, is a mental experience taking place in World 2, the world of subjective knowledge. (In an *objective* sense, thought is a neural process of which very little is known - it is obviously complex, involving perhaps many neurones which are not necessarily localised in one area, and hence not simply definable.) Of course no one individual can be aware of more than a very small part of World 3, and indeed it has become increasingly usual for university students to specialise in such studies as disciplines, relevant to the solution of problems later in life, when such knowledge may become a marketable commodity. The knowledge of World 2 is essentially therefore the subjective product of *interaction* with the objective knowledge of World 3. It is important for the academic student to understand the relevance of the need to ensure that conscious brain activity in the area of World 2 is subjective to the individual in the sense that the activity is directed academically to acquiring only *objective* knowledge from the vast cultural reservoir of World 3. World 3 objective knowledge should be (in modern times) the product of scrupulously *objective* interaction with the physical objects and states of World 1. For example, a qualified and experienced GP when he thinks about a case clinically, may have thoughts retrieved from various experiences acquired from his World 2 by interaction with Worlds 1, 2, and 3 - including some from the World 1 of the actual patient he is treating. Of course, his thoughts are not all stored in and retrieved from that GP's memory - he may rely on current literature, recent research or his computerised records.

The purpose of the Three World explanation given above is to give the university student some conspectus of the academic mental activities in which he or she is supposed to be engaged. The purpose of the system as represented above is not of course to explain the whole purpose of life. But the intention of all that has been said so far in this study is to clarify the reasons for certain activities and procedures which are usually taken for granted, but which in fact are not always understood or explained. Academic education is a large-scale, complex corporate activity, with certain objectives in mind, and it is always a help in such cases to know what the objectives are, and the means by which the objectives may be attained, and what contributions are expected from the individuals involved.

For these reasons, in the opening chapters an attempt has been made to put those principally involved, university students, 'in the picture'. Fundamentally, the picture is of thousands of individuals engaged in the corporate and systematic activity of availing themselves of such parts of the corpus of human knowledge as may be useful in the certain specialist activities later in their individual lives. In the chapters of Part I, it has been considered appropriate to stress the workings of the individual Brain and its Self, as well as to impart some information about the principle instruments used in selective investigation of that corpus of knowledge. The principle instruments used by the individual are the human brain, and human language, and those other instruments used in the cultural transmission of knowledge. Together, as the foregoing explanation of the Three Worlds intended to clarify, these constitute a kind of system made up, like all systems, of elements interacting in order to achieve certain states. These elements (the human brain, the Cosmos and human language) are themselves also systems in the same sense, and are of vast complexity. This is not surprising, for control of complexity always requires complex systems of control.

The representation of the conscious interactivities of the human brain with its experience of the external world, as consisting of interactions of the various categories as described by Popper and Eccles, has been included as an indication of some of the implications of academic studies. Popper's and Eccles' intention was to work out, as a philosopher and a neuroscientist, certain philosophic and neuroscientific ideas. But perhaps drawing arrows on diagrams may not be an entirely satisfying way of representing the epistemological and neuroscientific problems, such as the relation between the mind and the brain, which anyway cannot be profitably discussed in the present context.

Instead, it is intended to explain in terms intelligible to first-year tertiary students an approach to some of the problems that their academic studies present. Something has already been hinted of this approach, for it is an approach that emerges from the history of the development of human language and human knowledge, and which involves the systems and ideas about those systems which are the subject-matter of academic studies.

It can hardly be denied that it is useful for the student to have a reasonable grasp of such systems as the human brain and human language, of their history and how they be might used to acquire reasonable grasp of the desired knowledge.

Something has been said of the working of the brain, and the writer has reason to believe that students would gain by knowing much more, but there are limits; and the minimum has been relegated to appendices. It is intended however in Part II to say rather more about human language, its historical background, and how it is used especially in acquiring and culturally transmitting knowledge.

CHAPTER IV: LANGUAGE AND CONCEPTS

The schema of the Three Worlds of the conscious human mind indicated above is intended to represent the way the conscious brain integrates and systematises human experience of the external world in order ultimately to survive. For this purpose humans beings rely principally on systems of language. No doubt there were originally simple proto-languages. The cry of the infant might be the code for 'I want mother's milk' or 'I want the security of being in mother's arms'. But the complexities of the external world soon complicated matters, and language itself became more complicated[1].

It is convenient at this point to consider human languages in a wider sense as any means used by human beings to transmit knowledge or information, or communicate wants or needs, emotions and feelings, reasons and causes, in order to secure directly or indirectly the survival of the species. It is important to realise that all species communicate in some way whether by cries and calls, or gestures or colours or aromas. But human languages have evolved much more complex structures and systems. Human languages use sounds and marks on paper which conventionally refer to certain things or classes of things.

The infant's cry may physiologically be the reflex effect of complex sensations of thirst, or any one or more of a number of such stimuli, for life is never simple. It is important that in fact students should realise that there are other physical means of communication. These days, if there is danger, a person may shew a red light, which is a signal, not a linguistic word. Before language began, perhaps people scratched marks on the walls of the caves in which they may have lived to escape glacial cold. Sometimes these scratches took the form of drawings of the animals on which they depended for food. We cannot know whether they

[1] The development of human languge (prehistorically) is obviously speculative, but Jesperson (1922) *Language: its nature, development and origin* has some interesting suggestions.

signalled or said something or just expressed a feeling - like a work of art. Which it was we cannot know.

To provide an answer would require an explanation, and it could not have been long in the evolution of language before the need arose for a language to explain the meaning of language. Thinking along these lines has now brought us to a very significant point in this study, a point that is crucial if students are to make the most of their academic studies.

We have, in short reached the point where the need arises to consider the implications of 'thinking with concepts'. The realisation of this essential requirement, especially important in the cultural transmission of knowledge by institutionalised education, has only gradually developed and is perhaps not yet fully understood.

An understanding of how the need for such thinking arose may become clearer by speculating a little about possible origins of the 'concept' as a thinking device. It seems possible for example that the question may have arisen as to how many spears should be provided to a group of Palæolithic hunters of beasts in order to ensure a successful chase. Without a system of numbers, and the operation of counting, there can be no easy answer. Thus concepts (of numbering and counting) are needed. Clearly one spear among a hundred hunters pursuing a herd of twenty is likely to create only panic among the game. It might well be that the cave-drawings were intended to represent the problem to an innumerate *Homo sapiens* - we cannot know. It is however the intention in Part II of this study to investigate certain aspects of the origins and use of such conceptual thinking, and the nature of the systems involved[1].

The intention in the following chapters is to explain what is meant by the phrase 'thinking with concepts', as a method of thinking likely to be useful to academic students. A concept, in this educational or academic sense, is any term used to explain the workings of a system and a system as already mentioned, is

[1] The glossary might be consulted at this point.

anything that consists of a number of interacting elements, interacting in such a way as to bring about a change of state in that system, while a 'change in state' is anything that is recognised as such when it occurs. It seems reasonable to assert that almost all knowledge relates in this sense to systems rather than to isolated discrete events or items. An important example of such a system is the schema of the Three Worlds as described in the previous chapter. For this purpose human beings rely largely on a special usage of natural language, which was referred to above as 'thinking with concepts'. It is important to note that in the context of this study, any term used to explain a system in the above sense is a 'concept' - and if it does not help to explain a system, it is not a concept. Note that 'term' is, by definition, any word, phrase or symbol that might be considered or used as a concept. CCA, (as will be explained) refers to the critical analysis of such terms, as to whether they do in fact help to explain the relevant system.

For example, to explain certain phenomena, Newton in his *Principia Mathematica* selected a term, 'gravitation' and used it as a concept to explain the solar system; Descartes selected the term 'vortex' to explain similar phenomen in a different way. In time, Newton's explanation came to be preferred as more powerful, and gravitation became a concept in Newtonian physics, and 'vortex' did not. It remained a term used in a certain way by Descartes.

This use of the term 'concept' as stipulated above does not accord (so far as the writer is aware) with current philosophic usage, but this is not the usual philosophic context. An understanding of the term conceptual thinking and CCA as stipulated above is crucial to an understanding of much of what follows in subsequent chapters, and so this meaning must now be made quite clear. The source of these remarks is the writer of this study, and accords with the Whitehead-Russell Calculus[1]. The term 'concept', and its derivatives, may be used, as stipulated by definition.

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[1] For Russell's explanation, *Principia Mathematica* (1927) Vol 1. as far as *56 is used. For definition in the above sense, see p.11

To achieve this end, it is proposed to give selected examples of the development and use of conceptual thinking as it appears to have developed in the history of language. In using this historical practice, the writer is following the historical principles laid down by the original editors of the *Oxford English Dictionary*[1]. In selecting these examples, some use is made of classical Greek philosophy and mathematics, as these Greek writers in their poetry and drama seem to have been among the first to use concepts to explain systems (in the sense stipulated above). The concept developing from systems in this way may be noted, for example, in the use Plato in the Socratic dialogues makes of literary and other examples from Greek art.

The historic examples selected here are those of Eratosthenes, Euclid, Archimedes, and (centuries later) Galileo, Newton and their successors. In the course of considering these examples, something will necessarily be said of the theory of systems in the sense described above. It should however be emphasised that this does not directly involve the mathematical discipline of General Systems Theory, and certainly rejects the role the biologist Ludwig von Bertalanffy cast for GST in the generalisation of all science. However, an understanding of the significance of the theory of the system at least in an elementary form for undergraduates is surely essential in the context of this thesis.

The first of the examples of thinking conceptually about systems is that of Eratosthenes (276-194 BC). Essentially the problem Eratosthenes set out to investigate was the circumference of the Earth, a case representative but by no means typical of the principles involved in conceptual thinking. That he achieved a remarkable degree of success was astonishing, in view of the fact that two thousand years were to elapse before the results could be tested by objective observation, and at the time of Eratosthenes the 'cultural heritage' included virtually no information at all about the shape, let alone the size of the Earth. It seems that from the time of Aristotle (384-322 BC) there was general agreement, at least

[1] Murray's Introduction to OED.

among the more thoughtful, that things were not always what they seemed, and that the explanation of that most obvious phenomena of all, the succession of day and night, could not be explained by regarding the Earth as more or less of a plane surface extending in all directions, and the apparent rise and fall of the Sun as explicable in terms of the rise and fall of a stone thrown by a child, left too much unexplained. What happened beyond the horizon? Eratosthenes took the commonsense view generally held from the time of Aristotle, that the Earth was a sphere, and reasoned accordingly that the explanation of the alternation of day and night was due to the revolution of the Earth in the light of the Sun. His reasoning was indicated by the following diagram.

Eratosthenes' measurement of the circumference of the Earth.
Z represents the Zenith; *C*, the center of the Earth; *A*, the city of Alexandria; and *S*, Syene. The angle *a* is the angle to be measured; it is equal to the angle *ACS*.

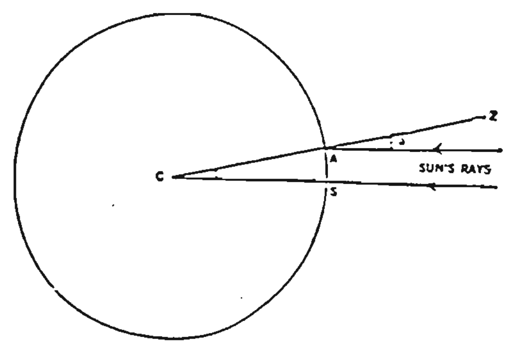

Figure 2. From Hall & Hall (1968) A Brief History of Science.

Consideration of this line of reasoning suggests that Eratosthenes was making a certain kind of assumption. It will be observed that he assumed that the angle subtended at the centre of the Earth was equal to the angle of the shadow-stick on the surface at Syene. It is of course equal, but this entails accepting a statement that is not directly observable, but which in turn follows from the study of a particular system called Euclidean geometry.

Consider then the example of Euclid (c.300 BC). Euclid compiled what is unquestionably the most remarkable text-book ever used for the cultural transmission of human knowledge by institutionalised education. Euclid's *Elements*[1] was in almost continuous use in the teaching of axiomatic reasoning from the time it was written until about 1960, when it was largely dropped from the

[1] Euclid (1956) *Elementa.*

secondary-school curriculum for reasons that seem obscure. Some of the concepts used and systems described dated from Aristotle, and these enabled Euclid to deduce (by axiomatic conceptual analysis) certain geometrical propositions, such as the celebrated theorem of Pythagoras. One of these propositions, as mentioned above, was similarly used by Eratosthenes to deduce his conclusions about the circumference of the Earth.

The significance of Euclid's achievement lay in his realisation that language could be used to add to our knowledge of the external world by means other than the observation of phenomena. The truth about the relationship between the sides of a right-angled triangle, though known to many surveyors long before the time of Euclid, could not be demonstrated by just looking at a lot of triangles. As we now know, a very great deal may be learned by using such systems of thought and soon after Euclid published his method - perhaps the first of all scientific methods - we find Plato making a grasp of Euclidean geometry a condition of admission to the Academy. For that reason it is considered necessary to include an explanation of Euclid's method in this study[1].

A few centuries after Euclid, institutionalised education in Alexandria declined, and eventually only Arabic translations of Greek mathematicians survived. Eventually these masterpieces were re-translated into Latin, and about the 16th century, they were taught in European universities. Thus after nearly a thousand years of neglect, these masterpieces stimulated the intellectual achievements of Galileo, Newton and others. It is significant to note that there thus arose a gap of over a thousand years in the development of conceptual and analytical thought. Alexandria had represented the first system of institutionalised education, based on teachers and great museums of manuscript books. Fortunately, when this learning again emerged to stimulate Galileo, Kepler and Newton, the era of the printed book had emerged, and institutionalised education revived in the period 1750-1950.

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[1] Appendix F (Axiomatics).

§ 1: Galileo and Newton

The next great step in the direction of modern systematised and conceptualised knowledge was the achievement of Galileo Galilei (1564-1642) and Isaac Newton (1642-1727). It is convenient and appropriate to consider their achievement as joint, although they were not strictly contemporary, and Galileo's contribution was systematic, while Newton's was conceptual.

The outstanding example of Galileo's systematic approach is indicated by the apparently historical account, as a youth of about seventeen, of his observation of a lamp swinging in a church in Pisa[1], when he asked himself whether the oscillations were isochronous or not. There were then no sufficiently accurate clocks to measure such short intervals of time, so he used his pulse as a measure, and was satisfied that the oscillations were isochronous. He was not then a student of natural philosophy, and though he later invented the pendulum clock, apparently he then did not consider the physical significance of his discovery. But at that time, astronomers were much interested in the problems associated with the motion of bodies in space generally and in the orbits of the planets in particular. In time it was realised that the swinging lamp was in effect a system, a pendulum, and its oscillations were isochronous because the relevant elements in this system were constants, as we now know, in accordance with the algorithm : $T^2 = 2p\ (l\ /\ g)^{-2}$.

§ 2: Isaac Newton and the Origin of CCA

The point here is that the term 'gravity' had not as yet been applied as a concept, and it is now appropriate to explain how a concept is born. Some years before, Galileo conducted his famous experiments which shewed that freely falling bodies fell at a constant rate, irrespective of their mass. Thus the then popular belief that heavy bodies fell faster than lighter ones was false. Galileo's experiments

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[1] Sharratt (1994) *Galileo: Decisive Innovator.*

suggested that the explanation of the fall might be some constant downward force x which as measured by Galileo's experiments, might have justified the equation

$s = x * t^2$ . .(* being any modifier) . . . ..(1)

This force, it is important to note, is here termed x was later termed g and is now measured as g newtons, after Isaac Newton, had explained the concept of gravity[1] in his *Philosophiae Naturalis Principia Mathematica.*[2] published in 1687. Thus was born what has come to be regarded as the first academic concept (as defined above).

It is important to make this quite clear. The Galileo equation (1) above, under the Newtonian system becomes $s = 1/2g\ t^2$, being the result of Galileo's experiments with cannon balls and inclined planes. An actual value for g was never established by Newton, but long after, by Cavendish, with a specially designed torsion balance. The value of g may however be derived from the formula for the pendulum system given above, given careful experiment and calculation.

The attention of students[3] might profitably be drawn to these examples, for they exemplify the principles of CCA and systems analysis. It should be noted that Newton as a mathematician with his invention of the infinitesimal calculus was able to construct a system which enabled him to solve isomorphically related physical problems not only of falling bodies, but also of the solar and other systems.

Other implications should also be noted. Galileo, for example, without assuming the concept of gravity, was not able to explain to his inquisitors why a mass dropped from the mast of a ship moving ahead would not necessarily land vertically astern of the point from which it was dropped, or why, if the Earth revolved on its axis, bodies on the Equator would not necessarily be projected into outer space.

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1 Newton used the word 'Gravitas' in the original Latin. At that time 'Gravitas' meant Heaviness or Solidity, both literally and figuratively. In his English correspondence Newton used the word 'Gravitation'.

2 Newton (1969) *Philosophiae Naturalis Principia Mathematica / Mathematical Principles of Natural Philosophy.*

3 There are suggested exercises in CCA in Appendix C.

§ 3: CCA in Theory and Practice

Again, other circumstances may involve quite different interacting systems. For example, some years ago, a large satellite called Echo, in the form of an inflatable Mylar sphere, was projected into orbit.[1] Those who were responsible for maintaining it in orbit found that calculations based on the traditional Newtonian equation were failing to provide satisfactory orbital predictions. It was after a time realised that Echo's very small density relative to its large size meant that its orbit was affected by the pressure of the light of the sun falling on its surface. In an analogous way, arguments in the social sciences that depend on statistical generalisations, whether or not expressed in terms of probability, may fail to fulfil predictions in certain cases, such as in the Harris case[2] discussed later.

Hence the importance of meticulous description of scientific simplification of systematic complexities. Even so, there is sometimes a price to be paid, and students have often to be reminded that concepts like Newton's *g* are themselves often simplifications, even though evaluation of some kind may be possible. Different circumstances, and different academic disciplines involving very different systems, may require very different CCA. Galileo for example realised that the actual velocity might not necessarily be a direct function of the downward force, and only of that force. There might be some other factor. Suppose, Galileo might have argued, the distance of fall s is the resultant also of another factor x, then :

s = (resultant of x + resultant of other factor x) (the time factor t^2).

Newton himself seems to have been well aware (*hypotheses non fingo*) that it is never possible to assume that all elements in a system have been considered. In this connection, it is significant too, that nearly two centuries after Newton, the physicist Max Planck, in December 1900[3], contemplating a problem similar to Newton's - the source of radiant energy - likewise applied CCA, and likewise

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[1] Klir (1972) *Trends in General Systems Theory*, p.103.
[2] Harris case in Chapter IX below.
[3] Hall & Hall (1968) *A Brief History of Science*, pp.302-303.

produced a new concept, in a similar formula, a concept now known as Planck's constant. The formula is the basis of Quantum theory, and was developed as follows.

Planck reasoned from the concept of 'entropy'. This concept of entropy had been put forward by the physicist Rudolf Clausius (1822-1888) and Lord Kelvin as the basis of the second law of thermodynamics (which had been known as the 'law of the conservation of energy'). Planck's contribution cannot here be discussed in detail, but he concluded that 'entropy' was something (like the old idea of energy) that could be changed but not destroyed, and was radiated from the surface of particles, not continuously, but in small particles, or *quanta*.. The individual quantum was determined by the wave length of the oscillation (l) multiplied by the constant (h) and by (c) the velocity of light multiplied by the relevant integer (n).

Thus according to Planck's Quantum theory, the energy of oscillation could be expressed as nhc / l. This formula is the basis of the first and second laws of thermodynamics, and emphasises the significance and similarity of CCA in the academic work of two outstanding thinkers of the period 1750 - 1950: Isaac Newton and Max Planck, one soon after the beginning, the other towards the end of that period of two centuries. Both recognised that they were not dealing with an isolated phenomenon (like a vortex, or temperature), but with complex interacting systems of phenomenal elements. Note that both Newton and Planck seem aware of the analogy of *system*. It is relevant at this point to mention Rayleigh's Principle of Similarity, which may clarify both CCA and systems analysis[1].

This important matter of systems analysis, to which emphasis is given in a later chapter[2] is occasionally overlooked in the social sciences. For example, certain twentieth century psychologists attributed all human behaviour to what they called 'motivation,' without defining 'motivation' in such a way as at least to try to exclude all other possible interacting elements in the relevant system.

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1 In Chapter X,§2 (The Algebra of Systems).

2 Harris thesis.

The debt that academic learning owes to Newton is immense, for it was Galileo and Newton who made clear the necessity for conceptual thinking and the systems approach described above. It is essential that students and their teachers should be in a position to acknowledge this; hence its inclusion in this study.

It is however necessary, before concluding Part II, to make explicit to students the essential basis of the achievement of Galileo and Newton and its implications for the advance of modern academic studies. This lies in their systems approach to modern academic studies, provided it is not understood as an attempt to frame a general systems theory, still less as an attempt to redefine or criticise a classical Scientific Method. Such major objectives, it seems, are appropriate rather for a higher doctorate or treatise. The very much simplified version might be as follows.

§ 4: Systematics and the Systems Approach[1].

All systems, which comprise much of the human environment, consist of elements in which some or all interact so as to produce a change of state. A change of state is any state which is perceived as changed[2]. The purpose of analysing such systems is to determine the respective transformations of the constituent elements so as to make it possible to predict and if possible to control the changes to the advantage of the observer, in solving problems.

In an academic context, such analyses always involve the use of language that is frequently complex. It often begins with one or more stipulations about the use of language (such as definitions) in order to identify the elements and describe which individual elements interact and transform which other elements. Clearly, the greater the number of elements, the more complex the process of identification becomes, and the greater becomes the need for procedures of selection and classification, perhaps involving further assumptions.

[1] See Glossary, under *systematics.*

[2] Ross Ashby (1956) *An Introduction to Cybernetics.*

When any two elements in a system are considered, a change in one either will or will not be followed by a change in the other. If there is no perceived change in state, then the two elements are said to be invariable with respect to each other. An example is Galileo's observation of the isochronicity of one oscillation of the pendulum as against another. This constant element ultimately led deductively to the concept of gravitation as a constant in the solar system. It may happen that all the elements in a system vary successively with respect to each other. In physics, for example this may be described as a 'chain reaction'. One of the first encountered by human beings was combustion, a chain reaction of molecules producing heat. An analysis of such a system by a modern physicist may involve such concepts as molecules, thermodynamics, entropy and radiant energy. A concept is any term used to explain the interaction of variables and constants. Special difficulties arise with CCA in the social and behavioural sciences, and these are shortly to be discussed in first chapter of Part III.

Thus a modern explanation, by the disciplined use of systems, concepts, assumptions[1] and axiomatic mathematical logic[2] may add much more to World 3 than the ancient explanation of fire as something stolen from the gods by Prometheus. Modern science in this sense is often able to offer analyses and theories of systems which have great explanatory power. Such analyses and theories often suggest isomorphous systemic structures in other fields.

In concluding Part II, attention must be drawn to the significance of the thinking of Galileo and of Newton. It was Galileo who perceived the significance of considering the external world as a world, not of 'things' to be wondered at, but systems to examined and explained. It was Newton who, perhaps with greater perception, realised that the mathematical conceptual thinking inherited from ancient Alexandrian mathematicians, revived, retranslated and circulated as printed university text-books, provided him with an incomparable means of analysing,

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1 Appendix D (Assunptions).
2 Appendix F (Axiomatics).

identifying and then explaining systems in terms of concepts. It is not generally known that Newton first studied Euclid at Cambridge, when such axiomatic geometry was not widely taught in schools. But such geometry was to evolve new ways of thinking that will be more fully explained in Part III.

INTRODUCTION TO PART III
EDUCATION AND KNOWLEDGE

§ 1: The Search for Scientific Method

The discoveries of Galileo and Newton mentioned in Part II were eventually to lead to a period of sustained intellectual activity and discovery that was to affect profoundly and at an unprecedented rate the whole way of life and thought of many human beings during the last two centuries and continues to do so. This delay needs explanation. The long night of mediæval gloom that followed the intellectual achievements exemplified by the Hellenic civilisation of Alexandria, eventually gave way to the dawn of the Enlightenment that resulted from the discoveries by Galileo and Newton, as discussed in Part II above. However, it was over two centuries after the publication of Newton's masterpiece that gloom really began to disperse.

The great libraries of manuscripts and the academies of Alexandria, and the scholars they encouraged were dispersed after the sixth century A.D. and learning and teaching declined for nearly a thousand years. These centuries of illiteracy meant that it was nearly two further centuries before there was a wider reading public for the huge output of the Aldine and other presses could be read and the full implications of Newton's methods could be understood.

Newtonian and other advances in the realisation of academic studies as perception of systems rather than observation of 'things', were further delayed for nearly two centuries while the people of Europe learned to read the printed book.

§ 2: Newtonian Science

In addition, as will be explained more fully in the following chapters of Part III, the full implications of the academic nature of the basic methods of Galileo, Newton, Locke and others were not at first - and perhaps still are not - fully appreciated.

In Part II an attempt was made to shew how after nearly a thousand years, thinking with concepts revived, in the eighteenth century due largely to the thinking of Galileo, Copernicus, Kepler, Newton, Kant and others. Before explaining the intellectual results that were to inaugurate the intellectual and cultural advances of the last two centuries, perhaps greater in their effects on almost all aspects life than ever before in history, it is necessary to consider in historic perspective, the intellectual situation as Newton left it. It is only in the last few decades that the relative importance of such an historical approach, in the work of Thomas Kuhn[1] has come to be recognised because the value of historical surveys depends on many factors . It is hoped that the importance of the survey may become progressively clearer.

Newton's discoveries as set out in his ***Principia Mathematica,*** were commonly acclaimed as the greatest achievement of the human mind, and so indeed they were, in the sense that their isomorphic applications were so vast that they helped to explain so many analogous problems. However, what is relevant at this stage of the study is that the very immensity and range of the Newtonian discoveries caused people to believe that Newtonian learning and thought had established the human mind and methods as able to solve eventually all problems and reveal all the secrets of nature. It was thought that Newton's philosophy was essentially deterministic; namely, that provided that all the elements in a system and their magnitudes were known, then all possible outcomes could be predicted, just as in Newtonian statics and dynamics. It was all simply a matter of analysis of cause and effect.

This interpretation of Newtonian views lasted for many years, and occasionally is still given expression. It found its most eloquent expression in the nineteenth century in the logic of John Stuart Mill (1806-1873) and his 'methods' of analysis of causation, which failed largely because his analysis did not allow for the plurality of causes in complex systems. This complexity did not at first prevent

[1] Kuhn (1970) *Structure of Scientific Revolutions.*

successive attempts to construct a 'scientific method' which it was believed might make it possible ultimately to devise 'scientific laws' from which might be derived predictions making possible the solution of many if not all of the problems that the external world presents. However, in the post-Newtonian world, events (which must here be condensed) brought about an awareness of the misery and poverty which the advance of 'science' brought about, and with it came an increasing desire to improve the lot of human beings, with the help of the 'scientific' methods still popularly attributed to Newton.

§ 3: The Age of Science

There can be little doubt that Newton, and those who broadly shared his views of what he regarded as natural philosophy, had in spirit departed from considering those studies as based on the axioms of corresponding mediæval studies. Newton himself, like Euclid, was well aware in constructing his mechanistic theory of the great difficulty of presenting satisfactory justifications for those beliefs. Newton had his own axioms, which he expressed in his four rules.[1] These are:

1. We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.
2. Therefore to the same natural effects we must, as far as possible, assign the same causes.
3. The qualities of bodies, which admit neither intensification nor remission of degrees, and which are found to belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever.
4. In experimental philosophy we are to look upon propositions inferred by general induction from phenomena as accurately or very nearly true, notwithstanding any contrary hypotheses that may be imagined, till such time

[1] Thayer (Ed.) (1953) *Newton's Philosophy of Nature*, pp. 3-5.

as other phenomena occur by which they may be made more accurate or liable to exceptions.

As mentioned above, Newton in fact had made certain mistaken assumptions about the nature of time and space, about inertia and the concepts of heat and energy. Some 19th century thinkers, such as Helmholtz and Kelvin, held the view that all phenomena of physical if not of animate nature were eventually explicable by a unifying mechanical theory, and it is sometimes claimed that this was Newton's view, though this view of Newton's ideas may well be mistaken, for Newton repudiated, in his rules, generalised explanations, and he would likewise have rejected such a positivist mechanism. At the same time, Newton's views were then held by many without reservation. Since Planck and Einstein, however, it has been realised that the original axioms of Euclid may not hold under all circumstances (in Riemann's geometry for example) and what is more significant, because not all arguments are deductive in the Euclidean sense. As far as Newtonian physics is concerned, Newton never claimed that his system was completely deterministic in the sense that it explained all phenomena, including gravitation itself.

What Newton had called natural philosophy, became increasingly to be referred to as 'science' or 'scientific knowledge', which was to be achieved by the application of 'scientific method'. The issue as to whether it is possible to devise a procedure or method that will produce general principles or 'laws' from which problem-solving predictions may be derived is highly controversial.

While it is certainly not possible to settle such an issue in this context, it is of such importance to students that it cannot be evaded. Instead, it is intended in Part III to describe in something like a historic state of play commentary, the changing course of events of the age of science, in terms of CCA and systematics. However in order to avoid distracting confusion it should be made clear that systems analysis, or systems theory (as described in the Glossary), is not itself a scientific method or complete theory of systems - many other assumptions and procedures would have to be added before such an epistemological claim could be advanced. The same might be said of Newton's four rules as given above.

Accordingly, also to be included in this Part, are sections on scientific and systematic thinking in the period from 1750 to the present hypothetico-deductive and nomological-deductive axiomatic procedures, axiomatic set theory, isomorphism and its significance, and critical conceptual analysis of statistical generalisation and random sampling procedures. This last is exemplified by discussion of an actual instance of relevant educational research work.

CHAPTER V: THE BEHAVIOURAL SCIENCES AND RESEARCH

§ 1: Sciences in general

From the mid-eighteenth century onwards, confidence in deterministic scientific procedures that would invariably discover and establish 'laws of nature', slowly diminished, beginning perhaps with the devastating criticism of David Hume (1711-1776) the sceptical philosopher who roundly dismissed any procedures that implied that it was possible logically to predict the future solely on the evidence of past events[1]. However many black crows have been observed, those observations cannot justify the claim that all crows are black - there will always be the possibility of an albino crow around somewhere; likewise, however many bars of copper are heated and have expanded, there always remains the possibility that at remote time, or point in space - past, present or future, there may be an exception. This was Hume's problem, and it never seems to have been successfully refuted, despite the efforts of philosophy students. Hume's objection has also formed the basis of refutation of many cause-and-effect analogies and arguments, such as the claim that "like effects are produced by like causes". In time, the suggestion was made that 'scientific laws' might be established by such procedures as the formulation of hypotheses and their experimental verification or falsification. Here grave difficulties arise over the formulation of the hypothesis to be investigated. It gradually came to be understood that much depended on the complexity of the systems involved. Galileo's pendulum and Newton's solar system turned out to be relatively simple systems - relative, say, to the complexities of human brain with its 10^{12} neurones. The oscillation of a pendulum, for example, according to Newton depends in fact on the length of the string, and the

[1] Hume (1976) *An Enquiry concerning Human Understanding.*

gravitational constant *g*, an element of which Galileo was doubtless aware, but was not then able to analyse. It is significant that Newton, with his four rules derived from his studies of more complex systems, was eventually able to analyse *g*. Anyway, the task of the medical research specialist is often complicated by the great complexity of the systems involved. Even Newton's task of analysing *g* was simplified by the fact that the force *g*, is very small indeed relative to the masses and distances involved in solar space, and relative to the greater force bonding atoms. Nineteenth century scientists became increasingly aware that devising scientific procedures, especially those that involved finding and experimentally testing hypotheses involving highly complex systems of interacting systems, could (and sometimes did) raise difficult problems.

The ultimate emergence of the social sciences owed much to the influence of the positivism of Auguste Comte (1798-1857), the founder of what he called 'sociologie[1]'. Comte held the then popular idea of the supremacy of the brain of Hss, as revealed by the impressive physical discoveries of the 17th and 18th centuries. This triumphalist view of science as eventually conferring on the human race with the capacity to explain all human and social problems, culminated in the shallow optimism brilliantly satirised by Voltaire in *Candide* . It was recurrent in the 19th and 20th centuries, though the incidence of the two World Wars of the 20th century has perhaps brought about a more sober attitude that led Gibbon to describe[2] history as "little more than the register of the crimes, follies and misfortunes of mankind".

What is of greater relevance here is that there eventually emerged the behavioural sciences of economics (and its progeny), and psychology (and its progeny), which are perhaps severally regarded as the principal social sciences. It is not so much the content of these sciences, as their structure that makes these sciences relevant to the current study. Structurally they exemplify the characteristic

1 (1843) O.E.D. on 'sociology'.
2 Gibbon (1887) *Decline and Fall of the Roman Empire*, p.72.

that really differentiates such sciences - the degrees of complexity of the systems involved in these sciences, and consequently the need for definitions, concepts, identification of systems, assumptions and procedures to explain them.

In short, the distinguishing characteristic of the behavioural and social sciences is the greater degree of complexity of the brain of Hss. The subject matter of such studies raises problems fundamentally different from those investigated by Newton and his associates, ultimately involving collective and individual behaviour and decision-making, and above all problems of investigating systems of biological cells, and thus of far greater complexity than those systems studied by Galileo, Newton and their successors.

Newton's approach was fundamentally mathematical - that is axiomatic, definitional and deductive. Hence it is important for students to understand that this means that it was systematic. For university undergraduates, this implies an understanding, not of GST, which is a specialised branch of higher mathematics, but of the elements of what might be called systematics[1]. Such an elementary study bears the same kind of relation to GST as does elementary mathematics to number theory at university level. The basic relationship and relevance of systematics to various academic disciplines in this context is perhaps best explained by considering the CCA of the term isomorphism. When that is done, there follows a discussion of two examples of an elementary systems-theory approach: the first a general problem, Charles Darwin's system of biological evolution; the second the specific problem of yellow fever in Panama in 1901. These two very different scientific studies are included to draw attention to extent to which the structure of the systems involved affects the very different nature of the respective studies, and accordingly of the methods and procedures involved. First, however something should said of a certain kind of pervading unity that may be significant even where variety of systems prevails. This unity in variety is called isomorphism.

[1] Consult glossary, under *systems, systematics*.

§ 2: Isomorphism and Systems Analysis

A general theory of systems is not a theory in the usual scientific sense - as is the kinetic molecular theory of gases. It is, as suggested above, a kind of 'grammar' of systems, a study of functions, types and structures, intended to facilitate the understanding, explanation and solution of problems[1]. It is concerned with the various forms that systems may take. Attention has in fact already been drawn to the importance to students of perceiving analogies between sciences and systems. The entomologist studying social insects like ants and bees may find he has something to learn from the vocabulary and approach of the sociologist; the psychologist studying problems of human behaviour may learn from the economist's analysis of human economic behaviour; something may be learned from the analogy between systems and machines, as we have seen. The differential calculus is analytic; the integral calculus is synthetic. Certainly the neuroscientist and the computer scientist have common interests in their science of artificial intelligence (AI).

There is however something of value to be learned by the academic student from an isomorphic approach to systematics that may assist in understanding the structure of various sciences. The term 'isomorphism' in this context needs some explanation. The word itself is strictly a technical mathematical concept, but in the context of systems analysis it refers to a degree of analogy of characteristic elements between certain (not all) systems. A system is, or tends to be, isomorphic with another such system, if certain elements in one system (whether a science, or machine or factory or organisation) map on to certain elements in the other system.

Consider for example the following four sequences of numbers:

(a): 2,4,6,8

(b): 7,14,21

[1] What follows is partly prompted by an article by Anatol Rapoport published in Klir (1972) *Trends in GST*, pp 42-60.

(c): 3,5,7,9

(d): 3,6,12,24

Each sequence is isometric, in so far as it is in an ascending order of magnitude. But if each is considered more specifically, there are pairs which are isomorphic with each other, but not with the rest: (a) and (b) are isomorphic, in so far as the difference between each element is equal to the first element; (a) and (c) are isomorphic, in so far as the difference is always 2. But it is worth analysing the concept a little further.

At a more abstract level, (a) and (d) are isomorphic in so far as the operation of addition in (a) corresponds to the operation of multiplication in (d) - and with similarly varied description there are other isomorphs. The importance of this is that almost any two systems may be shewn to be isomorphic, provided they are described at an appropriate level. It follows also that isomorphic analysis, properly specified, can greatly assist student's comprehension of academic knowledge. The student could helpfully be advised to be always on the look-out for isomorphism.

Again, in Newtonian physics, whether the system is static or dynamic, motion is explained by analysing particular points at particular times; so the system is isometric in that respect. On the other hand, Descartes, in his theory of motion, classified bodies by their volume (extension in space). However this particular classification proved sterile, while Newton's proved fertile indeed. Again, in economics, it is usual to express demand in terms of marginal preferences, while at least some psychologists seem to express it in terms of 'motivation'.

It is important that students may profit from the foregoing by recognising the significance of isomorphism; and its relation to conceptual analysis is in devising explanations. Attention has already been drawn to the importance of definition and classification; and taxonomy has particular relevance to systematics, as has axiomatic set theory and elementary statistics, and the general idea of analogy and dysanalogy.

Elementary systematics involves, first an understanding of the relation of systems analysis to the concept and to thinking with concepts, which has, it is hoped, already been made clear earlier[1]. Secondly, systematics involves some understanding of the factors (historic, personal, constraints of subject-matter and so on) that determine the structure of a science.

In practice, moreover, students will find that sciences fall into various categories, though these are not necessarily isomorphic in origin. It is perhaps useful at this point to describe briefly certain typical categories:

1). The more highly developed physical sciences and disciplines (like Newtonian statics and dynamics) in which there is a certain number of postulates, definitions and rules of procedure. For teaching purposes, these are sometimes regarded as 'fundamental principles' of the discipline, but as has already been shewn, this does not mean that they are not open to critical conceptual analysis and systematic synthesis.

2). From sciences in this sense there are frequently derived less formal technologies - for example, navigation, some aspects of architecture, engineering and so on. Not all those who study a science need to do so critically.

3). From his optical studies, Newton derived a science of optics and formulated laws of reflection and diffraction. Likewise there is a science of astronomy with theorems derived from the observations of Kepler and Newton and the geometry of conic sections. Such sciences may not be as comprehensive as mathematical astro-physics or quantum mechanics, but they may nevertheless yield conclusions of value.

4). In addition, as Nagel points out[2], most sciences also contribute statements of great empirical value, experimental laws and theorems, and even single 'observation statements' of value, such as "digitalis is a useful remedy for certain heart conditions". In short, scientific knowledge is not the only useful

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[1] See also glossary, under *systems*.
[2] Nagel (1961) *The Structure of Science* p.351.

knowledge. There is 'folk science' too, like Chinese medicine, with its techniques of acupuncture, and herbal treatment; it is traditional, not scientific, in the European sense.

5) There is today thus no norm; no 'standard' or model or typical science. The basis of Newton's thinking in *Principia Mathematica,* and what has been for two centuries so influential, was in a sense a direct historical descendant of the Euclidean 'axiomatic' system. While it has its value as a paradigm in the sense denoted by Kuhn[1], it has its limitations when applied to behavioural sciences, as is discussed in the next sections of this chapter. Also there are the social and behavioural sciences, and these are considered in the two chapters immediately following.

While the various forms that individual sciences may take are influenced as to content by historical circumstances, such as the research interests of individuals, as to climate or local weather, the significance of GST at this point in the present study is perhaps greater. It is also pointed out that if mathematical systems are isomorphic, then they may well be conceptually isomorphic; and they can then perhaps be represented as analogous reductive systems. One example of this is the concept of entropy, also mentioned earlier. But isomorphism is relevant to the analysis of the elements in a system, and hence relevant to systematics, as a stimulus to research, not only in the social sciences, but also as a means of analysing wider concepts of knowledge itself, concepts perhaps not wholly appropriate to deductive analysis.

§ 3: Laws and Systems

Until about the beginning of the nineteenth century, the task of formulating laws and explanations to make it possible to predict human behaviour in terms of the 'positivism' of Mill and Comte, remained a formidable one. Because of the apparent unpredictability of human behaviour, it was evident almost from the late

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[1] Kuhn (1970)'*Structure of Scientific Revolutions, passim.*

eighteenth century that academic studies of the social sciences would involve special complexities, and require special methods. The trouble seems to have been that Mill and others did not know precisely where or how these social sciences were to begin. Mill and Comte sought a solution in a search for a kind of interdisciplinary scientific method, to be modelled, as they saw it, on the methods used with such conspicuous success by Newton.

Even in the early nineteenth century, academic thinkers were still somewhat carried away by the apparent positivism of Newtonian determinist physics, and they tended to overlook the necessity for critical conceptual analysis as a decision procedure, and the fact that, in addition, without the necessary means of observation of relevant phenomena, analogous to Newton's telescopes and instruments of more accurate measurement and calculation, the difficulties with their ultimate sociological objective, might be almost insuperable. Though not at first obvious, the most formidable difficulty, and one notably absent from Newtonian mechanics, arose from failure to recognise the complexity of the human brain and the CNS, with its countless millions of obviously interconnected microscopic neurones, and the implications of this consequent complexity of systems.

The absence of effective means of observation of phenomena, was not the only difficulty. What was perhaps of greater significance was the initial failure to recognise the need for developing a whole new approach, a new methodology and technique, and to the framing and assessment of hypotheses appropriate to the problems involved. Highly as Newton was esteemed, there was still little recognition of the weight that Newton had tacitly given to CCA and to the structure and significance of systems and their synthesis with other systems.

Of course, there was no difficulty about the formulation of novel hypotheses about human behaviour - there never is - but even two centuries after Newton there was still need for more specific and more testable hypotheses as the frontiers of science extended, as well as for recognising that other kinds of systems might exist in the other possible areas of social science (such a hypothetical as 'socio-neurophilosophy') In short, the possibility of a unified social science might not be assumed. This awareness and this need developed only slowly during and after the nineteenth century, and this different kind of approach is now referred to in various terms in different academic contexts. As will shortly appear, no one term is appropriate, for possible approaches are limitless.

An example of the new kind of approach made necessary by the extended scope of academic interests appeared in J.S. Mill's *System of Logic.*[1] There are many research methods and approaches other than just these two types of scientific method. As it is important that students should be aware of them, more detailed examples shortly be discussed in the coming §§ 8-10 below, in the research work of Charles Darwin and the rather different research into yellow fever.

§ 4: The Approach to Scientific Enquiry

First, however, it must be noted that the academic problem situations that attract human attention vary a great deal, and it as well to consider why this so. As Newell and Simon[2] point out, what at first sight appears as a single problem may on reflection appear to present a complex of problems. Perhaps there is an initial problem which has to be solved first, or the problem that first arouses curiosity is just a special problem which is part of a more general group of problems - as the apple, or stones, falling to the ground, was part of the wider problem of the Moon in orbit round the Earth, and the still more general problem of gravitation in the whole Solar system. Again, the problems and the solutions involved may not come in logical sequence, and the general solution of such complex problems may have to await various subsidiary discoveries. We still do not fully understand the nature of gravitation, as Einstein tacitly conceded. In fact, the history of science at least

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[1] First edition published in 1843. There is an account of his method in the two volume edition, Vol 1, p.500. Detailed criticism in, for example, Kehane, (1973) *Logic and Philosophy*, pp.261-264.

[2] Newell & Simon (1972) *Human Problem-Solving*. See also Appendix E on problem-solving.

since Newton, suggests that this kind of complexity is the rule rather than the exception, and it is this that makes necessary what is sometimes called scientific research before considering what appear to be particular problems.

Probably most students are familiar with the phrase 'scientific research,' though few, at least in their first encounter with the academic world, are able to distinguish between the various uses of the word 'research', or discriminate in the use of other terms associated with it - such as induction, theory, law, belief, hypothesis, experiment. Some aspects of these terms are dealt with as relevant elsewhere in this study. It seems, however, relevant at this stage at least to remove some of the confusions, to enable such students to answer satisfactorily the question "why is scientific research necessary?" Scientific research may not, in fact, always be necessary (e.g. within an axiomatic system) or always possible, but a student should be able to give a sensible answer to the question.

§ 5: Systems Research and Enquiry

It is not surprising to find something of a difference between what Newton called Natural Philosophy and what in the nineteenth century came to be called Science and scientific research. Newton studied significant elements in large systems, working with bold strokes on a large canvas, using methods of which he was a master, and means of which he was the creator. Those who followed did not always appreciate that they were more concerned with minutiae, and moreover they did not fully understand his methods, or the modifications entailed in working on a smaller scale with infinitely more complex systems. Where Newton had studied the motion of large observable masses relative to each other, and had the mathematical genius to devise and apply appropriate mathematical skills to make useful predictions, Newton's successors in the nineteenth century failed at first - and some still fail today - to recognise the constraints imposed on their very different task.

The relevance and significance of systems analysis and synthesis, especially in social sciences, was however by no means clear at the time of Mill and Comte in the mid-nineteenth century. Research of this kind has developed, and is still developing, only fairly slowly. Newton, moreover, had the advantage not only of 'standing on the shoulders' of Kepler, but also benefited from the systematic mathematics of Greek mathematicians like Euclid and Archimedes, centuries later retranslated from Arabic, and again taught in sixteenth-century universities. From Archimedes, Newton learned (Proposition 2), that "the surface of any fluid at rest is the surface of a sphere whose centre is the same as that of the Earth"[1]. It is not unreasonable to regard such studies as the beginning of modern academic systems research.

In the two centuries after Newton, interests in academic problems had greatly changed, as had the approach and methods employed. It is therefore appropriate to consider at this point an important example of the kind of problem, and the approach to it, that occupied academic attention just two centuries later. At that time (about 1860) the field of study suggested by Mill and Comte for academic and scientific study had not developed in the way or to the extent originally anticipated by Comte. Despite the immense labour Comte devoted to his *Course in Positive Philosophy* (1830-1842), his thesis on 'social physics' attracted little lasting influence, except perhaps on Karl Marx, who adopted Comte's general idea that societies develop according to laws of nature. It was, however, a work on a biological thesis on the origin of species that attracted very much more attention, and which will now be considered.

§ 6: Systems Analysis and Charles Darwin

In this work, the theory of evolution was first presented by Charles Darwin and Alfred Wallace in a paper to the Linnean Society in 1858 and later published by

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[1] Archimedes (1950) *On Floating Bodies*, Proposition II p.154.

Darwin as the *Origin of Species*. Darwin argued that the various kinds or species of living things had not necessarily retained the same form 'such as creation's dawn beheld[1]' as he had observed in the voyage of the *Beagle*, but they had evolved from generation to generation, by means of possibly minute heritable changes in such a way as to secure by hereditary (or genetic, as we would now say) means the survival of the fittest. It was, Darwin explained, these successive and often minute mutations that had - generation after generation - eventually resulted, even in the case of Hss, in the evolution of the human brain itself, and the many other specialisations that characterised other species.

The real significance of Darwin in this context was the evidence he presented in, the result of what might these days be called intensive field-work of meticulous physical observation of his subject matter, much, though by no means all, of it as naturalist on the *Beagle*. The idea that species emerged broadly as he had described was not original; what was original was the very detailed and logically arranged evidence, and the emphasis on adaptation. He argued that a species survived only because the 'chance' mutations persisted that enabled it to adapt to its environment. He did not agree with Lamarck that the animal itself produced or developed (somehow) the mutations it needed. Darwin himself was not much concerned with the actual mechanism that might ensure the transmission of these minor adaptations from generation to generation.

This surprising theory was greeted sceptically, not so much because it seemed to fall far short of the rigour of Newtonian physics, as because it placed too much emphasis on chance mutation, and did not allow for other (possibly supernatural) elements. As Darwin's friend Huxley pointed out, quite apart from the Biblical account of the creation of species, Darwin offered no evidence that the specialised evolving mutations could or would continue from one generation to the next. The sharper claw, or the more effective neuronal synapse, might occur as a

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[1] Byron (1963) *Childe Harold*, Canto 182.

mutation - but what *mechanism* would ensure its genetic transmission to the next generation? Chance had evolved the mutation; might not chance eliminate it?

Nothing in the scientific method that Mill suggested, no analysis of causes and effects, no hypothesis, in Darwin's time offered a suggestion or 'law of nature' to account for this phenomenon. The actual mechanism that might ensure the transmission of these minor mutations from generation to generation was in fact an aspect of Darwinism that was perhaps obscured by the Science versus Religion controversy. Darwin rightly felt that he was on the sufficiently strong ground of the evidence painstakingly exposed in the *Origin of Species*,[1] and on the evidence of horse and cattle-breeders, who for generations had profited by such mutations. As a result, there were of course those who still preferred the Mosaic supernatural explanation, and who pointed out that, for example, the son of a great classical scholar might not himself be a great classical scholar. Surely, it was argued, Darwin's theory of evolution was nothing more than an unverifiable hypothesis, which merely confirmed that it was impossible to build social and behavioural sciences solely on a foundation of Newtonian scientific methods.

At this point the controversy took a noteworthy turn in a methodological sense, which, by emphasising the importance of understanding systems, was eventually to affect research procedures in the twentieth century. An excursion into the history of scientific thought and method at this point may help students to appreciate what was to amount to an advance in the application of CCA.

It had become apparent that the Darwinian theory of the genetic transmission of characteristics, as originally presented, needed more searching conceptual and systematic analysis. J.P.Lamarck (1744-1829) had already put forward the hypothesis that living species might pass on characteristics by inheritance, and Charles Darwin had already pointed out that for centuries farmers

[1] Darwin (1929) *Origin of Species*, especially section on Morphology, Chapter XIV, pp.363-367.

had bred livestock with apparently desirable inherited characteristics. The mathematicians J.B.S. Haldane and Sewall Wright then shewed by a mathematical systems study that even very small selective advantages would cause genes in time to spread throughout populations. This suggested a new line of approach, a closer examination of the systems involved, and hence the need for further systems research.

§ 7: Systems Research and Neo-Darwinism

This introduction of what amounted to systems research was the result of the re-discovery in 1865 of the earlier experimental work of G.J.Mendel, an Austrian monk. Mendel had been able to establish the simple systematic structure of the genetic transmission of characteristics. The significance of this discovery was not at first appreciated by the Darwinians, or by the Mendelian geneticists. Eventually the part played by genes, and perhaps above all the discovery of the part played by chromosomes and the nucleic acids (RNA and DNA) by Crick and Watson in 1953, led to the establishment of the new science of molecular biology.

It is however not possible to trace in detail the steps by which these results were reached, except to emphasise that the process involved a great deal of analysis of systems and isomorphisms. It further emphasises that students may profit by considering such research in terms of CCA and systems analysis. This kind of research may be especially significant with the social sciences.

Not many scientists would agree that molecular biology, as it is ordinarily understood, is a social science, though it is certainly 'scientific' in the sense that it does enable those who are sufficiently skilled in its techniques to explain and justify a good many predictions, and it certainly has put neo-Darwinism on a much firmer basis than the original version of Darwinism. What had happened was that Mendelianism had directed attention to the essence of Newtonian science - the importance of viewing phenomena as manifestations of *systems*, not mere occurrences of isolated events. Gravitation was not an attribute only of the Earth, but of the whole Solar system. Mendel's search for a regular pattern in the transmission of characteristics in ordinary garden peas was the analogue of Galileo's search for isochronicity in the oscillations of the pendulum - both sought to understand the systems involved. Mendel's system was not a social system, it is true, but it was a *system*, and required to be understood as such. Its significance lay in the focus on the problem of inherited characteristics and the need for systematic analysis of the mechanisms that Crick and Watson investigated. The neo-Darwinians were the biologists that realised the relevance of their discovery to the Darwinian theory of the origin of species - it strengthened it at perhaps its weakest point

There have been claims made from time to time that, for basic social theories of a causal kind, certain variables or sets of variables explain the state of a society. However, although elements in the geographical environment (such as climate, distance from the sea) may perhaps explain the state of a society at a given point of time, such a claim does not in itself establish a system of scientific laws explaining the behaviour of social groups as a system. In short, as Nagel says[1]

> The social sciences today possess no wide-ranging systems of explanations judged as adequate by a majority of professionally competent students, and they are characterised by serious disagreements on methodological as well as substantive questions. In consequence, the propriety of designating any extant branch of social enquiry as a 'real science' has been repeatedly challenged - commonly on the ground that although such inquiries have contributed large quantities of frequently reliable information about social matters, these contributions are primarily descriptive studies of special social facts in certain historically situated groups, and supply no strictly universal laws about social phenomena.

'Motivation' in cognitive psychological theory is a case in point.

Nagel is of course not referring here to biological studies, but more specifically to social sciences, especially those concerned with explaining the behaviour of human beings in social groups. Since the above was written over thirty years ago, Nagel might today agree that biological studies and studies of

[1] Nagel (1961) *Structure of Science*, p.449.

social behaviour have a good deal in common, isomorphically speaking. In fact a zoologist, Konrad Lorenz, has suggested a that the common ground should be the science of ethology, and now ethologists concern themselves with the ecological behaviour of some of the more highly evolved forms of animal life, while some social scientists prefer to consider themselves as behavioural scientists.

Students need to be reminded that, immense as was the advance in human knowledge that *Principia Mathematica* constituted in 1687, Newton himself realised that he had by no means fully understood all the elements in the system, and that his understanding was incomplete when it came to very small particles. Consequently, his analysis of the concept of inertia has since been modified by Quantum Theory and the concept of entropy in thermodynamics. Likewise, as mentioned above, the advances of Charles and Boyle with regard to gases have since, for analogous reasons, been modified by the Kinetic Molecular Theory of Gases, as has atomic theory generally.

§ 8: The Basis of the Behavioural Sciences

The preceding §§ 6 and 7 involve reference to *two* succeeding attempts (Darwinism and later Neo-Darwinism) to explain behavioural (meaning here 'non-physical', but not metaphysical) phenomena. There is first Darwin's attempt to explain the phenomena he encountered in the voyage of the *Beagle* and elsewhere, which led him eventually to reject the original Biblical account of an act of Creation of all living things as separate species, in favour of an explanation of his own. Darwin's explanation replaced the concept of creation in a Biblical sense of fully developed species by the concept of various forms of life in the process of what came to be called evolution as explained in the *Origin of Species*. The published results of the *Beagle* experience aroused furious controversy, mainly on religious grounds; but it was also open to increasingly serious objections on the logical and scientific grounds just indicated. Be it noted that Darwin, like Newton in his four rules, also rejected 'supernatural' causation of events as unscientific.

Those who wished, before the advent of molecular biology, to defend the early Darwinians were in a position analogous to that of Galileo during the controversy between Galileo and the Church. Galileo was asserting a whole new and coherent systematic way of explanation, which no isolated contradictory example of the old Ptolemeic system could invalidate. Likewise, Huxley and his friends, in supporting Darwin's theory in the *Origin of Species*, were attempting to explain and justify a system, as yet incomplete; and, like Galileo, they found themselves confronted by inconsistencies based on the old system. The implications of Lyell's fossil discoveries, fortified by the observations of Darwin and Wallace, had strengthened the case for the origin of species by the evolution, through mutation, of the fittest to survive. It was in time realised that the concept of evolution itself needed the equivalent of CCA on the part of Darwin himself. Second, the system itself needed to be identified. Third, the interaction of the elements of the system required investigation. Consider these in order.

First, Darwin replaced the concept of the Creation of each particular species with the concept of the evolution by progressive mutation of various species, but he did not offer a complete explanation of the whole phenomenal system.

Second, the actual workings of the system were not, in this respect, critically synthesised, for there was no guarantee that the mutation would be transmitted and survive to improve subsequent generations of the species.

Third, this made necessary the third consideration, the mechanism that Mendel had described, but not explained. The explanation was the final step in the more detailed completion of the system, the later work mainly of Crick and Watson. It is also worth noting the contributions of Haldane and the mathematicians to the work of Mendel, and later of Crick and the Cambridge biologists.

It is particularly significant that the great procedural advance that molecular biology involved was not due to superior methodology or to the solution of Hume's problem. Advances in the frontiers of knowledge, students need to note, more usually arise from the CCA of particular problems, together with the specific and appropriate systems analysis. It is, as in the case of the theory of evolution, a matter of critical conceptual analysis and the appropriate systems analysis.

What it amounts to, as one modern philosopher[1] has expressed this wider research issue, is the realisation that "sometimes people have adequate evidence, and sometimes they do not". Research, based on the study of the structure of systems and of CCA, is an important part of ensuring that the evidence is adequate, and that its explanation does justify the conclusion. It is the intention and purpose of most of the remainder of this study to attempt a fuller and more detailed answer to this question, based on developing what has already been said. As is shewn in the last few chapters[2], there may also be added to the research procedures described above the requirement of explanation in terms of qualitative analysis.

As suggested above, a scientific method may be regarded as any systematic procedure the aim of which is to acquire objective knowledge or information that may be useful in the solution of specific academic problems. (Whether it is successful or not is a matter for systems and CCA.) In the past some writers have made things difficult for themselves by thinking in terms of a single specified routine procedure applicable in general to all scientific enquiry. This has often been uncritically referred to as '*the* scientific method'. This is about as misleading as to talk of *the* mathematical method, or *the* technological method. For example, the

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[1] Strawson (1952) *Introduction to Logical Theory*, p.257.

[2] Chapter IX §6, also Chapter X.

Newtonian method of mathematical principles and models was hardly appropriate for explanation of the origin of species; even had Darwin included systems analysis. Academic problems may, as will shortly be suggested by the example now to be discussed, may differ enormously.

There are different scientific methods, just as there are different scientific problems, and perhaps also different solutions and different solvers[1], which a glance at the history of science will shew . One kind of procedure emphasises the knowledge or information as being in the form of generalisations or inductions, the so-called Baconian method as described in *Novum Organum* (1621); another emphasises the interaction of causes and effects, as does Hobbes in his *Leviathan* (1651). In more recent times, the positivists, like Mach, have tended to follow the Baconian tradition, while Duhem (1861-1916) has rather relied on mechanisms, concepts and systems. Methods of thinking and observing and procedures in scientific enquiries have led modern physical sciences to develop in terms of descriptions and predictions, so that from simple observations of directions of forces we are able to predict future paths of moving masses. This kind of scientific procedure often owes its successes to the fact that the observables are usually measurable properties, yielding what some regard as testable theories and hypotheses. For this reason, a scientific procedure that is based solely on such statistical support may be recognised by some scientists and not by others.

§ 9: Experiment and Explanation - the Panama Canal.

What part then does evidence play in explanation? The point is that an explanation should include testable consequences, and so it is thus relevant to consider the part played by experiment in explanation. An explanation is satisfactory if it achieves its intended purpose which is to explain some system to an interested person, and provided it also is confirmed by repeated testing. The explanation is a function of that system, and it is the stimulus of interest in the

[1] See Harré (1960) *Logic of the Sciences*, p.44-47.

solution of a problem that prompts the activity of explanation. The explanation itself takes a certain form and has a certain content. What this content is, is decided by the student, and depends on the nature of the problem and the systems involved, and the skill of the explainer. If the explanation succeeds in communicating clearly and convincingly the suggested path to the solution to a problem, then it is successful as an explanation; if not, it fails. As an aid to explanation, experiment can be very useful indeed, or it may point the way to another approach. It will be helpful now to consider such an example[1].

Such an explanation may be clear and convincing, and hence (as an explanation) it may be successful; but a detailed chronological account of the discovery of a solution to a problem may be less useful in the long run than a more analytical explanation involving the tracing of causes and effects.

Notice that the explanation does not necessarily contain the solution. For example, consider the solution of the problem in Panama in 1901. In the late years of the 19th century the decision was made to cut a canal through the isthmus of Panama, then part of Colombia, and Ferdinand de Lesseps, who had been associated with building the highly successful Suez Canal, was made responsible. The dense tropical jungle and fearful climate, together with deaths from fever, maladministration and waste, caused the attempt to be abandoned, until the United States set up the state of Panama, took over the enterprise and began anew. The greatest difficulty was then seen to be the very high mortality from yellow fever among the construction workers, and a commission was sent by the US Government to Havana in 1900 to determine the aetiology of Yellow Fever. The Commission then proceeded, in accordance with what was then seen as correct scientific method - hypothesis and experimental investigation. Accordingly contagion was first investigated, and volunteers wore the clothes and slept in the beds of former patients - with negative results. Then the *Bacillus icteroides* was suspected and again tried on volunteers, again with negative results.

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[1] This example is partly derived from Nidditch (1960) *Logic of Science and Mathematics*. p.253.

Another hypothesis was put forward by a Cuban doctor, Carlos Finlay, that the fever was caused by the bite of a mosquito, *Aēdes aegypti stegomyia.* Twenty-two cases of yellow fever were produced experimentally, 14 by infected mosquito bites, six by the injection of blood, and two by the injection of filtered blood serum. The last two suggested the existence of a filterable virus. In 1901, one of the members of the Commission was Jesse Lazear, in charge of the experimental mosquitos. While engaged in placing live mosquitos on patients in a fever ward, a free mosquito was seen on his hand, but it was allowed to feed on his blood. Five days later he was taken ill, removed to a fever hospital where he died after seven days. So the result of Lazear's heroic experiment was mortally affirmative. From these experiments, the Commission was thus able to establish empirically that yellow fever was transmitted by the stegomyia mosquito, that the human incubation period was two to six days, and that an infected person cannot infect a mosquito more than two or three days after the onset of fever. The life cycle of the mosquito was thereupon carefully studied, and, as with malaria, the cycle of the virus included passing into a vertebrate. As the mortality rate was very high indeed, vigorous steps were taken to exterminate the mosquito, and in the Canal Zone it soon ceased to be a problem.

It is significant to note that the solution (of the high mortality) which had been first been recommended by de Lesseps, was to abandon the Canal project altogether. Noting that a written *description* of such a cure is of course not itself a cure, what kind of explanation was likely to lead to the solution of the problem? The general answer is, it depends on the kind of problem.

This provides an interesting example of a problem being solved by taking immediate and repeated experimental steps not so much to find a cure, as to find an *explanation*, and profiting by that explanation, a decision to remove the cause of the problem - the mosquito itself. No treatment for yellow fever itself seemed effective, and most who contracted the fever soon died of it, so prevention was indeed better than cure. The resolution of solutions does not often happen quite so promptly, except where the pressure for explanation and action is very great - as for example in time of war.

In this case it is particularly significant that precise instructions were given to the Commission as to the systems they were to investigate in order to formulate the necessary scientific laws (as they were viewed), and those instructions the Commission scrupulously followed. This evokes the comments that Immanuel Kant (1724-1804)[1] addressed to his students that their attitude should not be that of a pupil who agrees with everything the Master says, but that of an appointed judge, who compels the witnesses to answer the questions asked. And that is what happened so strikingly in this case. The gallant Lazear did not want it to be confirmed that he was a victim - but he and his brother scientists wanted the truth more.

§ 10: Experiment in the Sciences

The part played by experiment in the Yellow Fever case in the previous section is particularly relevant at this point. It should be clear that, although experiments do not 'prove' statements to be true or false, the role of experiment in developing knowledge is important.

> In the history of science it is always the theory and not the experiment, always the idea and not the observation, which opens up the way to new knowledge; I also believe that it is always the experiment which saves us from following a track that leads nowhere: which helps us out of the rut, and which challenges us to find a new way.

By this somewhat sweeping observation, Popper[2] means to emphasise two of the main points that he makes in his celebrated *Logic of Discovery*. First, that the principle of all research and experiment is to consider only falsifiable hypotheses and theories; secondly, the need for rigorous scrutiny in the whole

[1] Cassirer (1982) *Kant's Life and Thought*.
[2] Popper (1959) *Logic of Scientific Discovery*, p.106.

procedure of 'corroboration' of scientific research; that is the theoretical research. No decision can appropriately be made about what experiment, if any, is to be used until the preliminary research - the systematic conceptual analysis and synthesis - is completed.

Thus the CCA and synthesis is of prime importance, for this should disclose to the investigator what the problem is. The problem is not always what it seems to be when unanalysed, as the yellow-fever case shewed. The real problem, it turned out, was not to find a cure for yellow fever, but to prevent sufferers from dying, which (investigation shewed) was to prevent mosquitos infected with virus from infecting human beings with that virus. This was done by destroying all the mosquitos, or at least preventing them from biting humans. There lay the solution - suggested by the explanation of the investigating Commission. That, of course, was not the end of the matter. Teams had no doubt to be organised and trained to use appropriate insecticides. In the same way, Newton had not only to invent the calculus, but also a suitable symbolism devised to enable it to be taught and efficiently used. Indeed, quite often the real objective is to devise an explanation that will enable a solution to be understood and taught in a way relevant to a particular problem.

Explanations in the physical sciences often involve experiments devised to meet this and other purposes. Such experiments were a frequently used technique in late 18th-century physics and chemistry laboratories. The procedure was often described somewhat as follows, and closely approximates to what was described above as the 'hypothetico-deductive method' :-

1). The first step may be to formulate a testable hypothesis, or rational guess, as to what general 'rule' might explain the phenomena under investigation:

2). The next step may be to deduce logically from that hypothesis some statement that would be experimentally confirmed if the hypothetical law were true, and falsified if it was not confirmed:

3). The third step (sometimes very complex) is to design the experiment:

4). The fourth step may be to carry out the experiment, if appropriate under laboratory conditions:

5). The fifth step may be to check the results, and write the description and explanation of the experiments, with a clear idea of the purpose of the explanation, and the persons for whom it is intended.

It is particularly important to note (as already explained) that whatever the outcome of the experiment, it cannot 'prove' any categorically generalised law. This may seem surprising, and perhaps the yellow fever example above may superficially suggest that an experiment may prove such a law. It may justify certain policies and decisions, without demonstrating that a particular statement is always true.

In fact, however, a person became a victim of yellow fever only if[1] bitten by a mosquito when the mosquito itself had been infected by that particular virus. It is significant that many mosquitos were not so infected, or had ceased to be infectious. Many people were bitten by mosquitos at that time in that region and had survived unharmed, and Lazear himself, although indeed bitten, might very well not have died.

This issue is important at this point in our discussion, and must be explained fully. Consider carefully the procedure as described above.

The first step is often not easy, as it is sometimes not possible to formulate a testable experimental hypothesis. For example, to conduct an experiment, you have to be able to manipulate the system or systems involved, usually but not always, in the laboratory, and thus if the hypothesis involves manipulating the Solar system, then experiment would not be possible. In that case, the scientist may have recourse to observation. It may be that some celestial event - an eclipse, perhaps, or transit of a planet across the disc of the Sun may provide the required evidence. In that case, the scientists perhaps persuade the Government to send a Captain Cook out to the Pacific to observe the transit of Venus and report results.

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[1] See exercise on IF in Appendix H.

For the confirmation of certain aspects of his theory, Einstein in 1908 had to await an eclipse of the Sun. Many other hypotheses are untestable - whether there really are fairies at the bottom of the garden, for example - or whether there is life as we know it somewhere else in the Cosmos - or whether an academic activity (like that of Cook) may not produce a bonus discovery, like the east coast of Australia.

§ 11: Experiment in the Social Sciences

The matter of experiment in social sciences has already been referred to a number of times, and will be dealt with in a way much more fully relevant and practical to the context of this study in Chapter IX. There are however one or two appropriate comments to be made at this point. It was suggested earlier in this chapter that generally speaking the subject matter of the social sciences, as Nagel points out in a passage quoted above, "possess no wide-ranging systems of explanations judged as adequate". Yet experiments not only in the social sciences, but also in the physical sciences, often need careful qualification, and then they may have great explanatory value. This explanatory value arises from the explanation itself, for the explanation, to be really satisfactory will make quite clear exactly what is being assumed. Suppose, for example, that the best available measure (no measure can have absolute accuracy) still leaves a small possibility of error, then if the explanation clearly shews that this error is insignificant in actual practice, then of course the error is assumed and the explanation may still have its value.

Certain conclusions that have emerged in the course of this chapter must be emphasised. First, mere speculation about possible causes and effects is not enough - some knowledge of the system or systems is required, and whether or not the explanation involves measurables or ordinals, and perhaps the application of axiomatic set theory. As the contributions of Mendel and the molecular biologists shewed in the case of neo-Darwinism and as is explained in the next chapter, this knowledge of the nature of systems is even more necessary with behavioural and social sciences, for they differ in important ways from the Newtonian physical sciences. Second, it was explained that these important differences arose from the axiomatic systematic structure of Newtonian science, which axiomatic structure imparts a rigour to Newtonian physics that the early social and behavioural scientists did not at first fully appreciate. Finally, what means are in the event adopted depends on various factors - the kind of data to be studied, the instruments available for the observation of such data, the logical formulation of the hypothesis to be tested, and sometimes the personalities of the scientists themselves, and the traditions, usages and concepts of the relevant sciences - all these may need to be considered.

It may be helpful to review in isomorphic terms the two cases considered above - Darwinism, and the Panama yellow fever cases. A system is, or tends to be, isomorphic with another such system, if certain elements in one system (whether a science, or machine or factory or organisation) maps on to certain elements in the other system.

Here we have at least two main systems, that associated with the Origin of Species, and that associated with the Panama case. To what extent are they isomorphic? Anything like a detailed study of the isomorphs involved would lead to an impossibly lengthy digression, for as usual, there are, not one but many systems involved, so only main systems can be mentioned here. With Darwinism, the case eventually resolved itself into the science of genetics, a branch of molecular biology, and the main isomorphic element being the cell, and the main problem therefore the relation between the cells. With the aid of the electron microscope, it has been possible to discover a good deal about the interactions between the many systems of systems involved, in genetic systems, there are systems of chromosomes, in turn composed of DNA molecules. It was eventually discovered that the frequency with which mutations occurred was related to certain chemicals and ionising radiation. Cells in the human brain (neurones) are particularly complex, so much so that little is known of the interconnections, and consequently regularity of sequence of events, the significant isomorph is difficult to establish at the molecular level. Success is more frequently achieved, when the elements are on a larger scale, as in the Panama case, where a solution to the problem appeared when the infected mosquito bite appeared as the significant constant. In some studies, investigators sometimes settle for more easily identified behavioural phenomena, like motivation, or the Id, or Ego, or Self, or Soul as the object of investigation. This is of course a perfectly permissible academic procedure, and often leads to successful solution of specific problems, provided the concepts are critically analysed - as in the Panama yellow fever case. But note that no cure for yellow fever was found, but the death rate was greatly reduced. Thus when the problem seems intractable, such as a universally effective cure for malignant cancer (probably a kind of mutation), the problem remains.

It is at least clear that in considering the two problems, the Darwinian and genetic problem on the one hand, and the problem of yellow fever in Panama on the other, from the point of view of their isomorphism, they had at least one set of elements in common - they were both concerned with a search for constant regularity of sequence of events. Darwin was concerned with transformation in systems from being the more general to the more special - how species evolved from the genus to the species; in the Panama case, what brought about the transformation from reasonably active labourers to dying fever-ridden patients. In the first case it was mutation in cells; in the second it was the bite of a mosquito infected with the yellow-fever virus. In both cases, further study of the systems involved provided much more information. In the first, it led to modern micro-biology and genetics; in the second, to the study of virology. Both were concerned with systems very different from that of Newton, and so both involved very different methods of investigation and research.

It is this aspect, research, that is discussed in the next chapter.

CHAPTER VI: PROBLEMS IN RESEARCH

It is to be hoped that the foregoing chapters will have given some idea of what in a general way constitutes academic research, and that there is no one procedure, no one scientific method, that is applicable to all problems in all sciences. The range of possible investigations is far too great, as are the questions that might be asked. As the previous chapters may have suggested, the realisation that this, or something like it, may have been the case, has only slowly dawned on the human mind, and there are still many who think that there must be some way, some method of arriving at 'reliable' scientific generalisations or 'laws'.

One unfortunate result of the modern curriculum of institutional education is that sometimes students embark on tertiary academic studies with very confused ideas, about the actual subject matter of their studies. If, for example, no analysis, or later synthesis, of relevant concepts is even being attempted, confusion about the methods used by human beings to acquire knowledge, to build up sciences and apply them to the solution of problems, remains obscure and uncertain, sometimes for a substantial part of a student's academic career, or even longer.

It is the main purpose of this chapter to indicate the very considerable practical reasons why the reliability of such generalisations is invariably open to doubt. The reasonable student, as suggested earlier, is probably well aware that there may be some doubt, but most students, and even some teachers, may not always explain the reasons. It is the purpose of this chapter to attempt to explain at least some of the reasons, but, as most students are aware, brief and convincing explanations are not an easy matter.

Research in institutionalised education is a case in point.[1] Such research very often takes the form of investigation of the history of what is seen as a particular teaching problem and the means that might be used to solve such problems. The range of such problems over past centuries to the present is of course immense, and the methods that have been and may be used to investigate them have varied accordingly. The ancient and hallowed traditional methods included what have been called by a recent writer[2] on such research as the 'tenacity' and the 'authoritarian'. Both still have their adherents, but the former implies the very human tendency to defend what has been always firmly believed to be the case, although it may be conceded that it is theoretically doubtful.

Any belief may be questioned, just as Galileo reflected and doubted whether Aristotle, who was to the mediæval mind often the great authority, was right about freely falling bodies. The critical conceptual analysis discussed in earlier chapters specifically often instigates such reflection, as we shall see. Clearly, what is needed, if possible, is a method (or methods) of appeal when in doubt - in short, an appropriate decision procedure. It is inappropriate to assume that there is only one such procedure and, *prima facie*, it is unlikely that one method, even in the most general terms, will be equally effective for all of the infinitely large numbers of beliefs that may be invoked in solving the infinitely large number of problems that may confront the minds of human beings.

Here we are moving to an important point. We are discussing what are really different attitudes or methods of justifying beliefs, and at the same time questioning whether any particular such method may in fact achieve that end. Each of the methods or procedures named have one important feature in common - each method *in itself* claims infallibility - the method itself will not admit error. The method of induction is particularly significant, involving, as it inevitably seems to do, Hume's

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1 See Wilson (1972) *Philosophy and Educational Research, passim* for a clear exposition of the basic problem.
2 Beer (1966) *Decision and Control*, Chapter 2.

problem, which applies to each of the procedures discussed above. The basic problem has already been discussed at sufficient length. What remains for students to consider is, as it were, the shadow it casts

§ 1: The Problem of the Problem of Induction

Many attempts have been made to find a way round the apparent inconsistencies involved in the problem of induction, and in later chapters[1] some explanation of the present position will be offered. Before doing so it is appropriate to supplement the more specific aspects in the previous chapter with some general references to some systematic ways in which human beings acquire such knowledge (or mechanisms) as they use to solve problems. It is generally a sensible practice in such investigations to begin with the simpler forms and work towards the more complex. First, there are certain concepts to be analysed. A systematic way of performing an academic activity directed to an objective is generally called a method, while the objective of the activity in this general case is knowledge and understanding of the human environment in the widest sense, and amounts to understanding why elements in the systems that constitute the environment change from one state to another. Such systematic knowledge when used to solve problems is often called science, and the methods of presenting it in such useful forms are called scientific methods and procedures, some of which were discussed in the previous chapter. There are as remarked above many such forms, and many such methods, depending on the means of observation and the problem space itself. The first difficulty encountered here is that environmental phenomena are not always what they are perceived to be (for example, the Sanders illusion[2]), and the modern academic thinker is usually - though not invariably - aware of this possibility, at least since Kant drew a firm line between noumena and phenomena.

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[1] Mainly Chapter XIII § 8.

[2] See Appendix B. The significance of the Sanders illusion is that an academically educated person can geometrically analyse an appearence that deceives his senses.

Difficulties also arise when the subject matter involves complexes of systems, especially of interacting systems, which generate very large numbers of possible explanatory hypotheses, numbers so large that special procedures, as suggested above, are often necessary for the human brain to achieve even a tentative understanding of the systems being investigated.

It should not be necessary to remind the student that only very simple academic problems can be dealt with if we rely solely on what has been described above as genetically transmitted knowledge. For example, consider the case mentioned above. Animals as well as human beings have problems, and often have genetically transmitted ways of solving them. There is the example of grazing of cows in a field controlled by an electrified fence. With the cow, the mechanism might be described as reflex or autonomous, (or perhaps a learned or a behavioural response). Whatever its response, it responds in a cow-like way to the problem - very different from that of a human. To the cow, the problem is to avoid the unpleasant shock it gets if it chooses to ignore the fence; to a human being the response in such a case might be to find a way round the object that frustrates intention. The human brain, with its highly developed human cerebellum and other CNS mechanisms, may discover an alternative, if sufficiently 'educated' - for example, earthing the electrical current. Human beings are therefore concerned with methods and procedures other than the 'once bitten, twice shy' inductive method of the cow - or, for that matter, learning by trial and error.

It seems that with human beings there is a certain reluctance to forsake the inductive approach entirely, a reluctance which seems to influence certain of the procedures adopted to solve academic problems. These procedures are particularly associated with academic problems involving highly complex interacting systems and involving sets of systems. Nevertheless, though practically all logicians agree that the truth of the premises of a valid inductive argument does not guarantee the truth of its conclusion, many philosophers of science agree that the tendency to revert to quasi-inductive procedures is widespread, especially in the social and behavioural sciences, such procedures are often highly controversial, and the viewpoint expressed here may be just one of many.

It seems however appropriate here to attempt an explanation of such a viewpoint, partly because of certain textbooks in current use in colleges of education that imply the uncritical acceptance of what may well be controversial[1].

It is necessary for students to understand from the outset that the controversy arises from evaluating solutions of academic problems of a certain kind only, not of all kinds. The validity of the solution to a problem at least in elementary mathematics is a relatively simple matter, once the closed axiomatic system is fixed and understood.

The difficulties and the controversies arise and the certainty vanishes as soon as we leave the safety of the closed system and the system becomes open and indeterminate. In the physical sciences it is frequently possible to derive information from what the logician calls categorical generalisations. A typical example might be "All pieces of metal so far examined (or as yet unexamined) expand when heated". As already remarked, if such categorical generalisations are regarded as the conclusion of a deductive logical argument, the argument is certainly deductively invalid, because no experiment on a particular piece of metal can confirm the above example of a categorical generalisation. All it decides is whether or not that particular piece of metal expanded. Still less are we inclined to accept a categorical generalisation to the effect that "all students taught French by the X method passed the examination" if the only evidence in support of that assertion is that "all students taught French by the X method passed last year's test". The statements in the last few lines certainly do not imply that the X method is useless - in fact these statements do not imply anything at all about the X method, good or bad. For the evidence is, and remains, merely an account of a single episode. Furthermore, even if conclusion is qualified in terms of a given probability, such as, for example, if, it is asserted that statistical evidence shews

[1] Ary, Jacobs & Rezavieh (1990) *Introduction to Research in Education.*

that 25 percent of all Australians who smoke more than 50 cigarettes a day incur malignant cancer before they are 60 years old, then however many random samples are tested, there is no way of shewing that outcomes of the test will invariably and precisely confirm the assertion. In fact, there is no guarantee that any Australians will die of cancer.

Nevertheless, the categorical generalisation has a long history and still appears in one form or another in various attempts to explain wide varieties of research with varying degrees of logical justification. In its most persuasive and most popular form it appears in the procedure known as statistical generalisation. A simple example has already been given above[1], and an extended case will be discussed in greater detail in the next chapter. In this form the procedure is widely used and is indeed often regarded as a valuable tool of explanation and justification of problem solving beliefs. It is however two-edged, and requires more caution in its use than is suggested in many current textbooks, particularly, it seems, on educational research. The danger becomes all the more marked when the purpose is to confirm rather than discredit a particular hypothesis.

All this is no doubt very obvious, though not necessarily to less mature students. For them it might be noted that there are other possible mechanisms and methods that may be used to control the environment, by special systems and without the use of language. There are inbuilt neurological feedback mechanisms analogous to such devices as thermostats and governors like those on steam engines, or their equivalent in words (signals like danger! or beware!). In animals such a method may take the form of an 'instinctive' response or genetically transmitted coded devices ensuring behavioural responses to ensure survival. With human beings of course the methods may also involve language, and it is at this point that difficulties begin to emerge.

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[1] See above, Chapter VI, §12.

§ 2: The Falsification of Hypotheses

The difficulty arises partly from the use of language itself. The idea is that we can store experience in language and use these stores of knowledge to solve problems. But Hume's problem suggests that it does not always work like that. Even in the cow-and-fence example, it is possible that the lesson learned "never touch an electric fence" may protect the cow from such electric unpleasantness. But if we suppose the cow, having eaten all the grass in the enclosure, is faced with starvation, it may be better to risk the shock in order to avert starvation. Likewise, as the earlier example of heating metals suggested, no experimental individual testing can shew that *all* pieces of metal will expand when heated. Thus it seemed to logicians quite a long time ago that all scientific methods that depended on induction - on generalising on experimental or evidence - were unreliable and logically invalid. Indeed modern text books that deal with problems of scientific method often begin with a solemn warning, which is worth repeating. As one such book states[1] :"we now turn to an examination of inductive arguments in their role in the logic . . . of science - a note of caution is in order" and the author goes on to explain that we are entering a controversial area, and that while it is true that literally *nothing* in philosophy is accepted by *all* philosophers, discussions about the statement that "the truth of the premises of a valid inductive argument does not guarantee the truth of its conclusion" and about the problem of induction generally are in fact highly controversial. This is no doubt true. But students should understand that whatever forms the discussions may take, there is controversy about the status of inductive generalisations. Human beings have, it seems, a dispositional attitude towards induction, perhaps originating *before* the accumulation of knowledge by language and cultural transmission. This is of course speculation, but students at least need to be warned of the very real danger

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[1] Kehane (1973) *Logic and Philosophy (2nd Edition)* p.248.

of relying on inductive arguments. As a term, 'induction' still survives, but not as an academic concept, for in practice it does not explain an academic system.

This seems to raise the question, how then is scientific method possible? The short answer is perhaps best given in the words of Strawson quoted above. It is certainly not that the scientific method adopted and the conclusions that are reached by any such method are valueless; it is that the value of such conclusions is in terms of the adequacy of the evidence and the way it is presented in support of such conclusions. This in turn may be all very well as a short answer, but beyond that to some people it may be quite inadequate and unsatisfying. What one person may consider 'adequate' support, may not satisfy another. And not only do individuals subjectively vary, so also do problem environments. In some situations, the benefits that accrue may far outweigh the risks of any possible error.

This is today understood by most research scholars - hence the many qualifications and cautions they often make in their findings. On the other hand, the inexperienced student, unless warned, tends to regard such conventional cautions as mere rules which somehow transform uncertainty into dogma. It is clear that what is involved here is twofold. First, there is the problem of finding an objective way of appraising and evaluating the individual conclusions arising from the attempted application of a particular scientific method; secondly there is the problem of evaluating the particular scientific method, or methods, adopted to reach those conclusions. The problem is not invariably twofold, but may be simplified by first reflecting on the general problem of the whole array.

§ 3: Statistical Generalisation and Research in the Social Sciences

What is a scientific method? A scientific method is any systematic procedure the aim of which is to acquire objective knowledge or information that may be useful in the solution of scientific problems. The criteria of acceptability of an actual method are controversial, and often depend on the circumstances of the case.

Statistical generalisations involving random sampling and probability have, until mid-twentieth century, played an important part in the formulation of the hypotheses of the social sciences, in industry, in educational research, and, it is important to note, in many basic hypotheses of physics itself. Two important examples (already referred to above) are the second Law of Thermodynamics (the law of increasing entropy) and the gas laws (from which is derived the Kinetic Molecular Theory of Gases). For example, the gas laws do not indicate the unit pressure of the gas at a particular point on the surface of a container, but rather give the average or statistical pressure, on the basis of temperature and pressure. However, statistical generalisations of the kind "25 percent of all adult Australians etc." are sometimes considered to be in a rather different category. Although this statement may convey useful information in warning cigarette smokers of the risks they run, the statement does *not* imply (as would a categorical generalisation) that anyone will die of lung cancer because they are Australian and smoke a certain number of cigarettes a day. Such a conclusion would assume that smoking cigarettes alone comprises a sufficient and necessary cause of cancer. To establish such a causal relation might require very specific systematic conditions. Indeed, as implied earlier in this section, a disconfirming or apparently falsifying case for a statistical hypothesis. For example, even if in another sample test only 10 percent die, or they all die, that does not disprove or affect the validity of the original statement in any way. This follows from the fact that y percent of all A's may indeed die, even though y percent of the sample do not.[1]

Likewise, many experiments in educational research involve comparing the relative merits of teaching a subject by a particular method, or using one method rather than another. Again, this would entail the very difficult and often unnecessary task of establishing and identifying sufficient and necessary causes. In more specific terms, it would involve investigating all the variables that might possibly impair children's specific skills. To do so is not merely a difficult task, but

[1] Kehane (1973) *Logic and Philosophy*, p.290.

is in fact demonstrably virtually impossible. This last statement almost amounts to a declaration that, at least in educational research, the techniques and methods needed to produce statistical probability generalisations *necessarily* introduce assumptions which fatally flaw such generalisations. Such a statement may require substantial justification. It is however fair to say that although modern research in education has become, at least since about 1960, much more circumspect about such investigations and the effect of the possible variables involved[1], it is felt nevertheless that an examination of a typical research of this kind may go far to indicate the kind of errors and pitfalls that in practice do occur, and as such may have an important bearing on what follows in later chapters. An examination of such a research is to follow shortly. At the same time, it is relevant at this point to refer again to certain fruitless statistical attempts to evade the problem of induction, mentioned earlier in this chapter.

§ 4: Statistical Generalisation

It was mentioned above that statistical generalisations played an important part not only in the social sciences, but also in industry. Such probability generalisations, for example, are in effect the outcome of the process of random sampling in quality-control in industrial production and in market research problems. The purpose of quality control in manufacture is to ensure the requisite satisfaction of the customer - too little, and sales may be lost; too much quality-control is wasteful - and besides, a little built-in obsolescence may help later sales. Obviously, quality control of quality-control itself is important - 100% checks of output would be expensive, so samples are taken at judiciously representative points, though the sample items themselves will be random. The variable factors - specific machine efficiency, wear-and-tear, materials used - are tested as may be relevant to ensure the desired standard, which may be achieved by imposing suitable checks and controls.

[1] For discussion see Chapter X.

It is relevant here to raise an objection to the above criticisms of the nature of statistical generalisations on the basis of random samples. It is claimed that to regard such methods as fallacious amounts to condemning a valuable scientific method. But worded in this way, the objection can hardly be sustained. The method of quality control by random sampling certainly yields information of value to manufacturers, and they are aware that they profit by it. Consultant physicians frequently advise their patients of the statistical probability of successful treatment derived by this method, as in some cases they are legally obliged to do. That, of course is perfectly true. The significance to be attached to the information is a matter for the recipient to decide, and is irrespective of the means by which the information was acquired, and its evaluation by any critic.

All this might suggest an analogy to those interested in educational research - there is an input of teaching, and there is the desirability of controlling its quality so as to secure satisfactory output of educational achievement - quality of writing skills perhaps. But a closer study reveals certain dysanalogies which are, in various ways, highly relevant to this study. These dysanalogies arise, especially with the social sciences, largely because of the complexities of the systems involved. Awareness of this led an eminent scientist[1], a specialist in General Systems Theory, to the conclusion that "Science stands today at something of a divide. For two centuries it has been exploring systems that are either intrinsically simple or that are capable of being analysed into simple components. The fact that such a dogma as 'vary the factors one at a time' could be accepted for a century, shews that scientists were largely concerned in investigating such systems as allowed this method; for this method is often fundamentally impossible in complex systems."

It is accordingly intended in the next and later chapters to consider in more detail some of the implications of the difficulties caused by this 'complexity of systems'. For there are whole ranges of categorical explanations other than strictly statistical probability explanations to be explored, including deductive nomological

[1] Ross Ashby (1956) *An Introduction to Cybernetics*, p.5.

explanation, and sometimes specific eliminative cause-effect methods. To investigate these without involving lengthy philosophical excursions, it will however be appropriate first to consider the whole concept of research in the rather wider sense of systematics and CCA, and in a more analytic way.

It is often rashly assumed that a particular subject of research does not itself require prior historical research, and still more rashly assumed that the whole concept of research can be taken for granted. These are questions that it is in the interests of all students to give some kind of critical consideration if they are to make the most of their studies, and it is to these questions we shall turn in the next chapter.

CHAPTER VII: AN INTRODUCTION TO THE ELEMENTS OF SYSTEMS THEORY

As has been explained in earlier chapters, at least from the time of Newton onwards, scientists became increasingly aware that again and again what they found themselves trying to explain were the elements interacting in systems rather than individual phenomena. The systems might appear to be relatively simple, involving perhaps only a few large masses, distance, and a gravitational or other physical constant. Or, as in the case of Charles Darwin the systems might involve quite complex organisms, for example the systems within systems of the complexity of the human or animal brain. There have from ancient times often been philosophers and mathematicians who have searched for patterns and systems to facilitate explanations, and it is not surprising that in the twentieth century scientists began to think in terms of what might be called a scientific study of systems themselves, by which it might be possible to classify types of systems and describe and even account for their characteristics. Thus there emerged general systems thinking and analysis, from which there has more recently developed a mathematically formulated general systems theory (GST). Like artificial intelligence (AI), this is now an advanced mathematical study, and GST as such lies outside the range of this study Though the details cannot concern us in this study, a grasp of elementary systematics and its concepts has its value for students.

Scientists had long been aware that to formalise any field of study and give it a structure, axioms, definitions, rules of procedure, appropriate vocabulary and even symbolism is often a great aid to clear and objective analysis and synthesis. Various developments in logic and mathematics such as set-theory and topology encouraged thinking along these lines, and in the late 1920s, a German biologist published a paper[1] on the "system theory of the organism" which attracted significant attention. So also did the controversial Gestalt psychology of Köhler, Wertheimer and Koffka, which revived Aristotle's dictum[2] that "the whole is more than the sum of its parts". Although the study of general systems theory (GST) has developed a very considerable specialist literature, it has rather fallen short of some of its more ambitious claims, in ways not relevant to this study.

§ 1: The Origins of Systems Analysis

During the War of 1939-45, the governments of the Great Britain and the US employed certain eminent scientists to advise them on a very wide range of operational problems, and for that reason these scientists were drawn from many scientific and other disciplines. Among the earlier appointments were Professor Norbert Wiener, a mathematician, and Professor A. Rosenblueth, a biologist, both with a deep interest in the mechanisms of that most intricate of all systems, the human brain. These scientists, and many others, had for long expressed concern that academic scientists tended to think and work as though their particular science existed in a world of its own, with its own rules, methods, practices, doctrines and especially its systems and subject matter with nothing much to learn from or contribute to other sciences and other scientists.

When these scientists began to work together, they very soon realised how much they had in common. Wiener[3] recalls that one of their number, a physicist, had been working on designs for an electronic device that would interpret printed words into sounds, with the idea that the blind might in this way be able to read. By chance one of his scientific colleagues with specialist knowledge of the human brain chanced to pick up some circuit drawings of the proposed 'reading machine', and asked what it was about, remarking that it looked like a sketch of the neurone system of part of the human cerebral cortex.

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[1] von Bertalanffy (1933) *Modern Theories of Development* p.64.
[2] From *Prior Analytics.*
[3] Wiener (1948)*Cybernetics*, p.22.

In fact it soon became generally realised that at least the one factor that they all shared as scientists, was that they were each concerned with studying the interactions (or 'behaviour') of complex systems of one kind or another, whether organic or mechanical or electronic. From this realisation there has developed a whole new discipline, or series of interconnected disciplines - cybernetics, operational research, systems theory (GST) and AI, as mentioned above. It might also be noted that systems analysis played a very significant part in Allied logistics, strategy and tactics in World War II, perhaps because of the appalling cost of its neglect in the Great War (1914-18). One of the leading advocates was the personal adviser of the British Prime Minister.

This has brought about, and is bringing about, something of a revolution in scientific thinking not in the sciences only, but in thinking and problem-solving generally. And, to revert to the remarks above about personal computers, the future of this way of thinking is likely to be bound up with these machines and those properly trained to make the most of them.

Much has been said of systems and their analysis, and it may be useful to academic students to be familiar with the elementary characteristics of systems to enable them to recognise the simpler types, and how they may be understood, analysed and controlled. Such an understanding also has implications for the next chapter.

In the meantime it is appropriate to stress that of systems analysis in this sense represents an extension of the approach of Newton to the problem of explaining the movements of the sun and planets - it was a solar system to be explained in terms of the concept of gravitation. Likewise, many other problems Wiener and his colleagues Ross Ashby and Stafford Beer might isomorphically be considered in terms of systems analysis. Clearly such an approach may be of great value to undergraduate students. For one thing, it helps the student to decide on what is relevant, and what is not, once the boundaries of the system have been defined, since a system is defined in terms of its concepts, as explained above. Students of economics are usually made well aware of this; the various systems within the bounds of production, consumption, exchange and distribution are analysed in terms of their relevant concepts of the market, the firm, the industry, in the long run and in the short run. If economics students are to make the most of their potential, they must therefore be familiar with these concepts, and think in terms of their interacting within the relevant systems. The same applies, isomorphically speaking[1], with other disciplines.

A system was defined as a collection of elements that interact in such a way as to change the state of other systems, or the environment of the same system. It does not take very much thought to recognise that in this sense, almost everything is a system or part of a system, even an apparently inert object like a pebble, consisting as it does of atoms and molecules.

What is significant for academic students in their studies is to identify systems, and identify their elements and characteristic relationships of those elements. The family into which the student is born is a system, and it derives its significance from the way its members are related to the individual and to each other, and to its social environment There are many millions of such significant systems in the human population. The family, for example, derives its special significance from the detailed knowledge and understanding that individuals have of each member, quite apart from individual recognition of which is a parent, and which is a brother or sister. This knowledge and experience may be significant to the individual at least at certain periods in life. In short, in becoming aware of the relevance of systems, and in fact of elements that transform a mere collection of items into a system. It is this relevance that enables the individual to identify the items in a mere collection, and to define a system more clearly. The identification of

[1] Chapter V.

the elements in a system's analysis, and their interactionary effects, establishes the *relevance* of the elements within the system or systems.

It was pointed out earlier that it was not until the 18th century that the more general importance of thinking in terms of systems began to be widely realised. Before that time, thinking even with systems tended to be Aristotelian, and such thinking was, like that of Euclid, existential rather than relational. However, the relationship between things, in solving problems, may be more important than the things so related. This being so, it is clearly important to know something about the behaviour of systems, and their ways and varieties. The relevance of such a study to the behavioural sciences will be discussed in the following chapters VIII and IX. The phenomena that students are trying to understand have to be understood and analysed as systems, as also have *systems themselves* to be analysed and synthesised as elements in a science.

§ 2: Operational Research and its Origins

It has to be understood by students that the number and variety of relations to be found in systems is of course infinite, and hence so also is the need to understand the relations between elements. Each system moreover may consist of numbers of distinguishable elements. Somehow the modern tertiary student has surely to understand the importance of reducing what he is studying to this minimum level of systems. Just as in the old days of 'grammar and maths', in the primary and secondary school classroom activities were reduced to problems about 'things', at the academic level it is for the student to realise that 'things' must be reduced to considering problems about *systems*.

Just as sentences have their various possible structures in English composition, and mathematical problems have to be presented in appropriate algebraic, geometric or other mathematical form, so also have other academic problems at tertiary level to be presented in their appropriate systemic form. This again has its implications for the declared objective of this study as a whole.

Such presentation is not an easy matter. Lecturers generally are not familiar with its demands, and there seems to be no elementary or introductory textbook on systems analysis. In the early days of OR and GST, Ross Ashby[1] wrote and used an introductory textbook for Cybernetics (now out of print) but it was perhaps rather too specialised for primary introduction, especially in the examples given in the context of this study, though in many ways it is a model of what an adult textbook should be. However it is proposed at this point to attempt to outline briefly the status of the subject and to indicate its potential and relevance in this context.

§ 3: An Introduction to Systems Analysis

There have already been in the text above a number of references to GST, but a brief reference to the history of the subject is now appropriate. Interest in a theory of systems arose in certain academic circles in the 1930s[2], in the idea that problems of various kinds might more easily be solved if they were regarded basically as set against the environment of *system*, of which such academic problems formed an interactive and significant part - just as Isaac Newton and later Charles Darwin had found two centuries earlier.

It should not be difficult for students to understand that a subjective study and classification of systems as structures is possible, quite apart from their counterparts, if any, in the environment. For example, a system might tend to maintain itself in the same state; that is, it might be homeostatic. This 'steady-state' might, in the case of a steam-engine, be achieved by means of a 'governor', like that developed by Watt. Or it might rely on a thermostat. By definition, one of its characteristics will be that the elements that constitute it will either change their

[1] Ross Ashby (1956) *Introduction to Cybernetics.*
[2] von Bertalanffy (1933) *Modern Theories of Development*

state, or remain constant as a result of external operations; it will, in short, transform (or not) as the result of an external activity, or operand.

For example, consider a single-cylinder steam-engine as a system; the elements that interact are the cylinder, inlet and exhaust valves, piston and piston-rod, fly-wheel and so on. Each injection of steam acts as an operand ultimately doing work in effecting a revolution of the fly-wheel, the whole combination of interacting elements constituting a transformation. This simple single transformation is described as a closed, single-valued transformation, and the repeated revolutions of the closed, single-valued transformation may be applied as a series to do work. For a symbolic representation in GST terms see Chapter X,§2.

Again, a system may clearly be animate or inanimate, and accordingly have various characteristics as a result. It may include other systems, as an industrial organisation may include machines interacting with human intelligences. Or, like the Solar System, its elements may include large masses moving in orbit. In any event, a system, whatever its characteristics or function, may be observed and analysed. Systems theory attempts to determine objectively the properties and chacteristics of systems, so that their effects may be predictable.

In the early 1920s, as mentioned above a number of scientists in various disciplines in Britain and the United States and Europe began to meet regularly because they recognised that the one thing they had professionally in common was that, whatever their individual problems, they were primarily concerned with systems. Among them, were Beer, an engineer, Rosenblueth, a surgeon, Bertalanffy, a biologist, and Boulding, an economist. The movement, as a movement, represented a move away from over-specialisation, especially in the social sciences.

With the outbreak of World War II, especially after the USA joined the Allies, various members of the systems-analyst group, (except Bertalanffy, a German) and many others were recruited by the Allied governments to form special research teams to apply their special talents on various problems involving operational research (OR) as it came to be known.

An early example of OR in World War II came after the fall of France when seaplanes equipped with radar detection devices were being used in 1941 against German submarine attacks on British shipping in the Western Approaches[1]. The submarines, based on Brest, proceeded on the surface towards the Channel, and submerged when spotted by R.A.F. patrols. Unfortunately, successful sinkings were disappointingly few, and groups of scientists, known at first as "radar operational research teams" were appointed to investigate. As eminent scientists, they took a broad view of the problem, and not only flew on patrols themselves, but also questioned the basic strategy - "might it not be better to prevent the submarines leaving Brest at all". However it was considered wiser to investigate the tactical problem of ensuring that the depth-charge exploded when the submarine was in the immediate vicinity. As it was, the new tactical weapon, radar, enabled the submarines to be spotted, the depth-charge dropped and exploded by a pre-set hydrostatic firing pistol responding to water-pressure. Clearly experience indicated that the enemy submarines were frequently not in the position where naval policy had supposed them to be when the explosion took place. Enquiry revealed that the charge was pre-set to explode at a depth of 100 feet, as it was calculated that when the submarine spotted the plane, it would crash-dive, and by the time the plane released the charge and it was about to explode at the fixed depth, it was expected that the submarine would be in the immediate vicinity. This might be the theoretical expectations, but they were obviously falsified by events. The research team pointed out that clearly the point to which the charge and the diving submarine had converged was determined by the precise time that the submarine commander actually saw the attacking plane, which would be determined by such variables as visibility, alertness of those concerned, and perhaps other variables. The

[1] For a fuller account, see Beer (1966) *Decision and Control*, p.43.

researchers suggested the charge should be set to explode at 25 feet. This in due course was done, and the figure for sinkings in due course rose seven-fold, while a captured German submarine officer suggested that the Germans had attributed the increase in sinkings to the use of more powerful explosives.

More significant for academic studies, the wartime administrations were so impressed with the success of 'operational research' that the word 'radar' was dropped, from the phrase 'radar operational research' and 'operational research' (OR) methods, in conjunction with GST, in peacetime, became an established tool of administration and civil management. In this connection, it is important that students should note the OR emphasis on the simple but essential system involved in the original case was to ensure that the missile and target converged at the right moment. What it all originally amounted to was research to ensure that the most efficient use was made of available resources, whether radar or any other asset, military or civilian During the War, OR teams continued to make significant contributions to the solution of tactical and strategic problems.

When peace came, the same kind of procedures had applications in management studies. For example, when, during the War, strategy called for air bombing raids on enemy targets, large numbers of planes might depart within a short period at dusk from a given airfield according to a strict timetable. At dawn, after returning with their fuel nearly exhausted, they could not be expected to return according to the original timetable, and dangerous delays in landing occurred. The OR teams, recognising the queuing-problem model involved, soon developed mathematical formulae to minimise the risk. Such OR methods and solutions were obviously relevant in peacetime to problems, not only in supermarkets, but also in industrial production and commerce where analogous 'bottlenecks' might occur in assembly lines. The study of OR methods generally is now acknowledged as an important part of management and business studies.

It is perhaps permissible to digress briefly to draw attention, in its historical background, to the central importance of systems analysis and critical conceptual thinking. The central historical events of the 20th century from 1940 to the present, do afford some evidence that very careful attention to systems analysis, and its implications for all problems of organisation and control, if desired objectives are to be achieved. One outcome is the emphasis on computational thinking (including AI). It seems not totally irrelevant in this age of the computer to suggest that the kind of 'systems thinking' of Ross Ashby can be other than educationally stimulating.

The essential feature, and first step in OR, was the identification of the basic problem - for example, in the case of the submarines and depth-charge, was to construct a model of the system involved. (This vital first step in GST procedures of systems analysis is to be discussed in context in due course.) In the wartime case quoted above, the basic model was the convergence of an explosive missile and a moving target - a common military event. This being understood, the solution of the problem was simply resolved by appropriate adjustment of the firing-pistol. It was frequently found that the main difficulty was then to overcome opposition from the traditionalist 'set-mind', preoccupied with the obsolete procedure. Systems Theory was something new to the professional and the specialist, but its achievements became too conspicuous to be ignored. It has moreover possible interest for academic students.

After the War, many of the more practically minded of the OR practitioners turned their experience and OR expertise to the problems of large-scale industrial and government organisations in Britain and the United States, while the implications of General Systems Theory, stimulated by advances in Information Theory and computer science and AI, attracted a good deal of academic attention. In the 1960s and 1970s, the GST movement made great efforts in the academic world not only to encourage the growth of Cybernetics (the application of GST to efficient management in organisations), but especially in the United States considerable government support was given to discover the structure and application of many sorts of systems, including military defence, and in most branches of knowledge - natural, social and technological - and even on this basis to develop the somewhat visionary unifying general systems theory, as mentioned earlier.

There was at first some discussion about the general characteristics of systems - might they for example fall into broad mutually exclusive basic categories such as being 'open' or 'closed', 'static' or 'dynamic', 'determinate' or 'indeterminate'? Theoretically, there might well be a class of infinitely complex systems (for example, in institutions involving large numbers of human brains or personalities). Such a contingency implied difficulties for the social sciences and for developing a unifying GST of universal applicability. Unfortunately, at this point, in the late 1960s, the advocates of GST seem to have faltered for reasons which need not be discussed here[1]. The situation at the present time seems to be that the conquest of human beings over their own ignorance (as already observed) does not always progress at a uniform rate in all areas, and that pace may necessarily have to slacken over some periods of time while progress is made in others. It is here suggested that General Systems Theory may have some special relevance in the sphere of academic education, especially for students beginning their university careers, which relevance has as yet certainly not been fully explored. It seems appropriate therefore at this point to explain a little more fully the technique of Systems Analysis as relevant to this study.

§ 4: Systems and the Social Sciences

Systems analysis is briefly sketched in §2 Chapter X and suggests that systems analysis[2] has decided significance for students of social and other sciences by arousing an awareness of the complexity of the variables involved in many

[1] Beer (1966) *Decision and Control*, p.22.
[2] For more detail, see Chapter X,§2 (The Algebra of Systems).

systems. A human brain is clearly very much more complex than, say, a pendulum. and systems analysis may suggest a means of analysing such systems[1]. For the academic student, systematics should bring out the complexity, not the simplicity, of explanation in the social sciences[2]. It has been suggested by various social psychologists and others that a whole new approach is needed, using conceptual analysis to stress human beings, not as an 'organisms', but as agents, with powers and capacity to choose and to use language to monitor choice. To this end, the concept of 'ethogeny' has been defined[3] as "the discovery and identification of the mechanisms that give rise to habitual behaviour which falls between environmental contingency and self-monitoring and self-direction".

In experimental work, for example, this will mean analysing behaviour in terms of episodes and episode structure, of getting the agent to give in his own words his reasons for performing certain acts, and his view of the acts of others. From this material it may be possible to discover and formulate the rules that underlie behaviour, whereas if the organism is regarded in purely mechanistic stimulus-organism-response terms, then explanation is likely to be less than convincing to the scientist. To shew why this is so, and how systematics may help, students need to understand how the need for scientific explanation arises. The history of science gives a pretty clear answer to this question, for from earliest times human observers have been confronted with events, as Galileo was by the swinging lamp, which they appear reluctant to regard as random. If there was any semblance of regularity, the tendency seems then to 'explore' it, in the manner of Galileo[4], and quite often offer an imaginative explanation, such as "the god Ra driving his chariot across the sky". Such explanations might for a time be accepted and eventually come to be regarded as 'common knowledge'.

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[1] See Ross Ashby (1956) *Introduction to Cybernetics*, p.39.
[2] For an extended example, see Chapters IX and X below.
[3] Harré & Secord (1976) *The Explanation of Social Behaviour* p.9.
[4] For more details, see Harré (1970) *Principles of Scientific Thinking*.

Euclid significantly begins (as noted above) the *Elements* with five mathematical examples. of what he calls 'common knowledge.' In Euclid, maxims like "things equal to the same thing are equal to one another", although perhaps not equivalent to the mathematical and logical 'axiom', constitute a kind of 'exploratory' knowledge that is still highly significant for the modern scientist and for the student. It is exemplified in Galileo's essentially 'exploratory' approach to the pendulum. He had no idea about the periodicity, but it was just that he was trying to find out empirically exactly what did happen - just as he did later with his exploratory approach to freely falling stones. As Harré remarks[1], this approach is "not at all like the traditional idea of hypothesis, prediction and test." The investigator "may have no very clear expectations of what to expect, and aims to find out". Such an approach, however, represents an attitude that might be commended to the young academic student, as has already been suggested above. Students might do well always to question the generally accepted traditional 'common knowledge' - especially when it has not been considered in the light of CCA.

§ 5: Experiments, Models and the Sciences

If this critical conceptual procedure is adopted, the ground has now been cleared for investigation of the possible systems that may be involved in terms perhaps of systems analysis. What pattern the matrices may suggest will depend on the field being investigated. In modern science, chemists may find themselves investigating reactions and describing them in critical descriptions of the interchange of ions that may explain those reactions. Geneticists may discover, like Mendel, unexpected patterns in biological types, perhaps in the gene and chromosome transfers. Physicists may find aberrations in terrestrial electromagnetic fields.

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[1] Harré (1970) *Principles of Scientific Thinking, p52*

This in turn raises more profound issues. How are scientists to determine what the mechanisms are that generate these phenomena, or these aberrations? In some cases, like that of Galileo, and Newton - and Harvey, the mechanism itself may be readily observable. It is physically present and may be dissected and observed. In other cases, this may not be so. Harvey, for example, boldly claimed that the blood was circulated by the heart. This (as already explained) he had ascertained, but lacking an efficient microscope, he was able to observe only the larger blood-vessels and not the smaller capillaries. However, he 'posited' them, as Euclid and Newton would have said, because he knew they, or some similar mechanism, must be there. Likewise, after Pasteur and Koch had established their theory of the bacterial ætiology of disease, there was still the unexplained phenomena of the common cold and poliomyelitis. Then came San Felice and Bordet, who, like Harvey with the mechanism of the capillaries, 'posited' the mechanism of the 'virus'. In both cases, these mechanisms originally constituted a 'model' of what *might* account for the aberration, but which *might*, if it existed, in fact account for the aberration. (A 'model' in this sense is a frequent device in systems analysis and still is in management and other scientific studies).

There are, Harré suggests, two possible types of models - one is the 'iconic' model, which is so imaginatively conceived that it closely approximates to reality. In the case of the virus, the 'iconic' model (as the electron microscope eventually revealed) became what is called a 'paramorph', of which in this case the bacterium of Pasteur was the 'source'. In some sciences - neuroscience for example, this idea of a model is carried one step further. Paul and Patricia Churchland[1] describe models, which might be termed 'homoeomorphs' in which an actual model creature may be designed (though not necessarily constructed) using electronic mechanisms and tensor network circuits to model the possible working of parts of the brain. There may be limits to this however, as there is some evidence that the actual mechanisms are on a subatomic scale. Nevertheless, there

[1] See Churchland (1986) *Neurophilosophy*, Chapter 10 *passim*..

seem to be no predictable limits to the potential of human ingenuity. Consider, for example, the Turing machine[1], a rather different, but at the same time a highly significant, model. This leads also to the computational method[2] of research which is mentioned later, in the discussion of Marr on vision.

There seem also to have been significant changes in the perspectives of the conceptual approach since Newton's day. The Newtonian approach, as mentioned above, was essentially mechanistic, and regarded things as substances with various properties and attributes, which might change as the effect of causes operating on them from without, like an inert body being moved by a Newtonian force. Obviously there were difficulties in applying this to mental activities except in terms of a behaviourist S-O-R model, with an organism passively responding to stimulus. Harré suggests[3] that the response to this began among English and European scientists after 1770 and has continued to this day, and is expressed in concepts of agency, potentiality, spontaneity and power[4] - in the principles of quantum theory and the concept of the field. Its equivalent is also to be found in GST, in the concepts of determinate regulation[5], and power.

§ 6: Conclusion

While it would be pleasant to share the hopes of Harré for the progress of science along the lines suggested in the last few Sections, change in such academic matters is likely to come only slowly. The positivist and inductivist influences and attitudes are deeply entrenched, despite a certain amount of progress in qualitative analysis in social science research. Before however passing on to consider in the final chapters some of the more profound implications for junior academic students and their teachers, in what has been said in the body of this study, it is intended in

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[1] Turing (1937) *On Computable Numbers etc.*
[2] Marr (1982) *Vision*; and Appendix J.
[3] Harré & Secord (1976) *The Explanation of Social Behavior.* p.78.
[4] Davidson, (1980) *Essays on Actions and Events*
[5] Ross Ashby (1956) *An Introduction to Cybernetics*, p.235.

the next chapter to consider critically a representative example of modern social science research, and some of its more relevant implications.

CHAPTER VIII : EXPLANATION and SYSTEMATICS

§ 1: The Language of Knowing

As explained in earlier chapters, the human brain, when trained to express thoughts in logical, critical and conceptual language, provides human beings with greater powers of control over their environment than that of any other species. However, in spite of the immense value of language in this way, there are difficulties and imperfections, some arising from the nature of language itself, and some from other deficits in observation and research.

Before there can be understanding of the environment, it has to be observed. The species Hss, like all animal species, has evolved various sensory organs and systems which enable individuals to perceive to some extent what is going on in the environment. These organs of sense are however imperfect. We can hear with our ears and see with our eyes, but we cannot hear all sounds or see all colours, or detect all frequencies of the electro-magnetic spectrum, and so we therefore cannot see and hear what is going on in the TV studio without the aid of a special artefact - the TV set. Much more significant, as Kant pointed out[1] in 1781, we cannot see "things in themselves (Dinge an Sich)". Unless there is an appropriate source of light, we cannot, in total darkness, perceive spectral colours at all. Nor can we perceive electrons, for the only direct knowledge we have of electrons is due the activities of the brain of Hss.

What we see with our senses are sense-perceptions. For example, when we look out of the window on a fine morning we perceive a kind of colour photograph of the natural world, but it seems that there is no such image (like the image focussed on the exposed film of a camera) localised anywhere in the brain. All this activity is in the form of countless firings of the synapses of the neurones in various localities in the brain. The total experience perceived is the outcome of all

[1] Kant (1929) *The Critique of Pure Reason* (English translation by Kemp Smith). p.74.

this information-processing cerebral activity[1] of Vision, which, as David Marr points out, is more than an information processing task, for if we are capable of knowing what is where in the world, our brains must somehow be capable of representing this information - in all its profusion of colour and form, beauty, motion and detail. This is the outcome of the interaction of countless elements of systems, much more complex than the retina of the eye. It has its limits, as mentioned above, and the interactions may confuse appearance with reality. What is now involved are the more specific concepts, not only of explanation and research, but also of what students may think of broadly as beliefs, and further consideration of other related ideas, such as hypotheses, theory, probability, conviction, consensus - and perhaps such absolutes as ultimate truth. Terms used for such concepts indeed require Critical Conceptual Analysis, on which Kant placed such emphasis.

In this and the remaining chapters the intention is to discuss science and its methods. First, what is meant by Science? Here careful CCA is needed. Science is one thing, and the sciences are another. In much that has been said here so far, it has seemed best to refer to academic studies, for that is likely to be the prime concern of students, who often tend to think of science in terms of white coats and school laboratories, and only secondarily of intellectual people engaged in specialised studies. It is perhaps nearer to reality to refer to academic studies, and define those studies as activities associated with beliefs, and the reasons in particular cases for holding, amending, or rejecting them. In the present context we are mainly concerned with academic beliefsw studied in universities.

§ 2: Aspects of Beliefs

Once language came to be used in the form of sentences, the idea of beliefs must surely have begun. Beliefs, at least to the less mature student, vary a great deal in degrees of objectivity, for they are often partly determined by the

[1] The process is outlined in Marr (1982) *Vision*, pp.31-38.

individual's experience. In the educational atmosphere of a university, as the previous chapters have emphasised, the necessity arises for the disciplined and usually written expression of academic beliefs, which should conform to certain standards. While not all sentences express beliefs in some sense, many do. There are interrogative, imperative and conditional sentences, as well as propositional sentences. Propositional sentences generally indicate some sort of knowledge, and the degree of confidence felt may be expressed in the actual wording of the proposition. Philosophically speaking, a proposition is a sentence beginning with "I believe that ..., or, I feel that ...", or "I claim that...," The opening clause is then followed by a substantive statement sentence. The whole constitutes a proposition. Acquiring knowledge by means of beliefs on the part of an educated person is in marked contrast to the analogous process in an infant. The infant has to form beliefs about 'up' and 'down', about 'gravity,' about its parents, about the apparent flatness of the earth, and so on. The infant begins with the sense of touch, using lips and hands, and later other senses, and eventually language and the brain are used in conscious thought, perhaps using the mechanism of the Three Worlds described above.

Under the influence of modern institutionalised education, more mature beliefs may be acquired, including the belief that beliefs, however sincerely held, or with whatever degree of conviction, very often what the proposition asserts has proved to be false. Human beings in time recognise that teachers and wise and clever men, and even august academics and institutions might hold and teach beliefs for centuries, only to have them eventually falsified by further discovery - such for example as the discovery of gravitation and Newton's laws of physics. From the eighteenth century Enlightenment there emerged the belief, or a set of beliefs, that there were simple methods or rules of procedure (like experiment and observation) that might ultimately issue in what were believed to be 'laws of nature' which in some sense represented absolute and eternal truth - like, for example, Newtonian physics. Newton had indeed call his book the "mathematical principles of natural laws," and it was held that if such beliefs were to be understood, they must first be explained, and explaining them involved accounting for the reasons that had produced them, or alternatively giving reasons why they should be amended or rejected.

Even such beliefs as Newton's *Principia Mathematica* had its critics and sceptics, like Einstein, Planck and others who were able to discredit certain implications of Newton's laws. Moreover, the belief in an experimental scientific method capable of producing laws of great predictive power in social and other sciences raises logical, mathematical and philosophic problems. Something of the magnitude of these problems emerges when the more recent discoveries in physics in the twentieth century are considered; problems in sub-atomic physics, in thermodynamics and in the structure of matter and of the origin of the Universe itself. Many of the philosophic difficulties centred round the problem of induction, and the formulation of laws. As has already been suggested in the previous chapter, fields of scientific study seem increasingly to involve large complexes of interacting systems, and as a result, in the matter of beliefs, uncertainties and difficulties are multiplied.

§3: Observation and Experiment

In time, especially as a result of the work of Galileo, Kepler and Newton, an operational pattern of academic activity began to emerge, as the significance of the two activities of observation and experiment were increasingly realised. What Galileo did that Aristotle did not do, or did not do to the same extent, was to experiment - with a pendulum, with falling stones - that is, with simple systems and with elementary factors. In this way it became possible, from observation of small scale problems, to form some idea of larger complexes of interacting systems. In this way it became possible, within limits, to predict the effects of such systems.

One of the first more modern thinkers to try to discern an operational pattern in the activities of such investigators was Sir John Herschel (1792-1871). He remarked[1] that

> the only facts which can ever become useful as grounds of physical enquiry are those which happen uniformly and invariably under the same circumstances. This is evident: for if they have not this character they cannot be included in laws; they want that universality which fits them to enter as elementary particles into the constitution of those universal axioms we aim at discovering. (By 'axiom' Herschel means a simple basic regularity such as Galileo's falling bodies acceleration.) Hence, whenever we notice a remarkable effect of any kind, our first question ought to be. Can it be reproduced? What are the circumstances under which has happened? And will it always happen again, if those circumstances, so far as we have been able to collect them, coexist? The circumstances, then, which accompany any observed fact, are main features in its observation, at least until it is ascertained by sufficient experience what circumstances have nothing to do with it, and might therefore have been left unobserved without sacrificing the *fact*.

The next step is the formulation of laws useful in making predictions, on the basis of observation and experiment, either artificially or naturally occurring. Before dealing with that (§4:The Formulation of Laws), however, it will be convenient to give an example of such reasoning in terms of elementary systems analysis. The example quoted below is adapted from Ross Ashby[2].

> Suppose. like Galileo, a student is confronted by a simple pendulum, say 40cm long. It is, of course, a simple system, and as such consists of elements that interact to produce a change of state. That is, initially, all the investigator knows. In terms of systematics it is an object for investigation, and the intention of the investigation is to explain, to make specific, the interaction by describing the successive interactions. The student, provided with a suitable recorder, draws the pendulum 30 degrees to one side, lets it go, and records its position every quarter second. The successive deviations are 30deg (initial),10deg, and -24deg (other side). So the first estimate of the changed state **transformation** (changed state), under the given conditions, is
>
> 30deg 10deg
> 10deg -24deg
>
> Next, check the **transition** from 10deg: draw the pendulum aside to 10deg and let it go, and find that a quarter-second later it is at +3deg! Evidently the change from 10deg is not-single valued.

1 Quoted from Herschel (1846) *Preliminary Discourse on the Study of Natural Philosophy*, p.119.
2 Ross Ashby (1956) *Introduction to Cybernetics*, pp.39-40. To explain this, Ross Ashby uses axiomatic set theory, and a special symbolism.

This difficulty is typical in systematics, and is fundamental: we want the transformation to be single-valued, but it will not come so. (We want it so, because unless the transformation is **single-valued**, no single-valued prediction can be made).

The fundamental point is this - and its implications should be very carefully considered. It derives from the specific difference between the relevant system and the material object being investigated. Every material object contains no less than an infinity of variables and therefore of possible systems. The real pendulum - the object investigated - has not only length and position, but also mass, temperature, electrical conductivity, crystalline structure, chemical impurities, bacterial contamination, specific gravity and so on. Of course all of the possible could never be considered, and the attempt is never made. What must be done is to select the variables that are to be taken into account - these are the variables that make possible the single-valued prediction. Thus systems analysis is essential to academic investigation.

To return to the pendulum. What happened here at first was to consider only the "angular deviation from the vertical". Suppose instead the mass of the bob was taken as a variable - that clearly will not necessarily produce singleness of value. But if the vector {angular deviation, angular velocity} is used the desired singleness of value is achieved.

There is a further interesting example of the importance of meticulous systems analysis of variables in Galileo's law of free fall. It is too long to detail here, but what it amounts to is that the velocities of a falling body are in fact proportional to variable times, as Galileo realised late in life, and not, as the "Merton rule" had earlier incorrectly suggested, in proportion to variable distances[1].

The significance of this for the epistemologist and philosopher of science need hardly be stressed. For example, the required prediction may be achieved if a loose screw is tightened, or an impurity removed from a water supply, or an infection removed by an injection of penicillin. Gowland Hopkins discovered the importance of vitamins when singleness of value in the behaviour of rats on diets when vitamins were identified. Likewise, in random sampling it is the measure of probability itself - the odds - that is significant, and not the element of chance itself. There are many other applications of systematics to be considered, but further elaboration at this point would be inconsistent with the purpose of this study.

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[1] There is a full account in Drake (1973) Galileo's Discovery of the Laws of Free Fall, *Scientific American*; Jan-June, pp.84-92.

§ 4: The formulation of laws

In the earlier part of the 20th century there was a good deal of discussion about the formulation of scientific laws, partly provoked by J.S.Mill 'methods.' These methods, as Mill himself recognised, were flawed by their emphasis on the idea of cause and effect, which rightly emphasised the importance of regularity of sequence of events, but erred in ignoring the fact that the investigator is invariably concerned with systems, that is with plurality of causes - rarely with a single cause and isolated event, but complex interactions between elements in systems, or systems of systems - particularly in social and behavioural sciences. Although, as suggested a few paragraphs back, there may be a discernible operational pattern in such investigations, the search for a uniform scientific method generally failed; and now it is perhaps generally conceded all such investigations have failed[1].

In the face of the criticism that the ordinary language of discourse and the simple sentential propositions of a natural language were alone insufficient to formulate and communicate beliefs of the kind that Galileo tried to express in his *Dialogue concerning two systems* and Newton in his *Principia*. It was to be some time before it was recognised that what was required was an academic use of language by means of CCA and systematic synthesis.

Most university teachers seem aware of the danger for immature students of cultivating any over-simplified view of scientific method. Its imperfections soon becomes apparent. Consider the idea of 'testing a hypothesis' for example. It is not the hypothesis that is tested, but an implication of it. If the hypothesis is "all metals expand when heated," then that statement cannot be tested by experiment, for the experimenter cannot test *all* metals through space and time. So an implication of the generalisation is tested, and it is argued by the experimenter, 'if it is true that all

[1] Laudan (1987) Progress or Rationality? *American Philosophical Quarterly*, vol 24,1 pp.19-30.

metals expand when heated, then if I heat this sample piece of metal, it will expand, and the generalisation is true." But there are objections - it depends[1] on the kind of implication; is material implication, or strict implication? Or, the simpler objection of Hume's problem, or Herschel above. The objections are even stronger, when applied to the social sciences, teachers sometimes counter the imperfection of the 'hypothesis and verification' view of scientific method by emphasising the view that "in science, nothing is certain". The attention of students needs rather to be directed to the fact that this picture of 'scientific method' is a far cry from Galileo observing the lamp swinging in the Pisan church, or "Newton with his prism and silent face[2]", or Kepler considering the velocity of planets in elliptical orbits in the Solar system. or Darwin on the *Beagle* The answer is surely that there is no one 'scientific method'.

Again there is the intractable problem of inductive method, already discussed at some length in previous chapters. For university teachers and their students, as for logicians and philosophers of science, concern[3] arises because so many scientists have been led to reject inductive logic as a useful explication of scientific theories on (1) the sceptical ground that no scientific generalisation over an unbounded domain can be an object of knowledge; or (2) on the view that inductive logic cannot shew that universal generalisations can be justified by purely empirical evidence.

Mary Hesse[4] in a fairly recent paper seems to argue in effect that while there are real grounds for this scepticism, there is some justification for the inductive approach, subject to proper logical precautions. She is aware of the formidable practical difficulties of the problem of induction for scientific research (as was the

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[1] For explanation of the logic, see Lewis & Langford (1959) *Symbolic Logic*, pp.199-200.

[2] ...where the statue stood / Of Newton with his prism and silent face / The marble index of a mind for ever / Voyaging through strange seas of thought alone. Wordsworth (1950) *The Prelude*, Bk iii, p.250.

[3] Cohen & Hesse (1980) *Applications of Inductive Logic*, (1980) pp.200-217.

[4] Cohen & Hesse (1980) *Applications of Inductive Logic*, p.202.

late Ronald Fisher) of maintaining in effect that the "proof of the pudding is *not* in the eating," which seems so entirely contrary to all human experience. The philosopher of science is indeed faced these days with the dilemma, if not the paradox, of having to admit on the one hand that the intractable problem of induction compelling the conclusion that strict statistical generalisation is inadmissible as a foundation of knowledge; and on the other hand conceding that scientists are thus deprived of the notion of scientific laws.

Faced with this difficulty of determining what attitude to adopt towards *justifying* beliefs, teachers occasionally maintain the *obiter dicta* "in science, nothing is certain". However, like most other categorical statements, it should be understood within its own system. The attitude that the statement implies is, as explained above, perhaps the result of what came to be regarded as the "collapse of Newtonian ideas", when a kind of neo-positivism arose, which expressed itself in various forms, for example in the ideas of Karl Popper (who was not a positivist) of falsification and fallibilism, and the notion that science progresses by "conjecture and refutation". Polanyi, Lakatos and Kuhn modified and developed this on a more or less empiricist basis, to the extent that it has become the tendency in some academic circles, to teach that, there are no certainties in science, and that academic progress is by 'consensus'.

§ 5: The Consensus Approach

How then is this puzzle to be explained to students? Students realise that at least arguments based on any inductive support from any evidence are controversial. On the other hand, the ideas of Popper of falsification and fallibilism, and the notion that science progresses by 'conjecture and refutation,' would seem almost to leave only the conclusion that "in science nothing is certain". Such an answer is hardly acceptable. For one thing, the statement is clearly self-contradictory, in so far as it amounts to asserting that "it is certain that nothing is certain" How exactly can one be certain that nothing is certain? Hesse, at the conclusion (p.216 of the volume referred to) has unhappily to admit, like other philosophers, the great difficulty of determining precisely where what amounts to the bounds between probability and inequiprobability are to be drawn, where definitions are to be formulated, and where dysanalogies are to outweigh analogies.

§ 6: Conjectures and Refutations

Something must now be said of Popper's view[1] that academic beliefs are the product of a process of conjecture and refutation; that such beliefs, while they are testable and hence falsifiable, are mere conjectures, which if refuted, are immediately displaced by the refutation. Thus the store of beliefs are in fact, not stores of the true knowledge for the final truth (in Tarski's sense[2]) could never be recognised as final, but just as a step in the direction of truth.

In his now celebrated book[3], Thomas Kuhn in effect challenged Popper's epistemology on historical grounds, by explaining that scientists did not necessarily abandon their 'paradigm' of their science because a particular anomaly appeared to falsify a conjecture. Such a refutation might merely provoke a 'crisis' and perhaps lead to a 'revolution' in the relevant assumptions of that science. The result has produced a lively controversy [4], especially challenging to the 'scientific methodists' and inductivists. The result has been to emphasise the significance of the historical approach, as previously stressed in this study. It would seem that there may be no specific operational procedure that will produce valid academic beliefs. The problems raised in academic studies and the complexity of the systems involved are too vast. It is certainly possible to describe certain procedures and practices that may often lead to the amendment or rejection of particular beliefs, and to the discovery at least of things hitherto hidden, and certainly neglect of other

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[1] Popper (1970) *Conjectures and Refutations* . The basic ideas derive from Popper's epistemology of falsification as developed in Popper's (1934) *Logik der Forschung* .

[2] 'Correspondence', Popper (1968) *The Logic of Scientific Discovery*, footnote, p.374.

[3] Kuhn (1962) *Structure of Scientific Revolutions*, and for a stimulating discussion of some of Kuhn's ideas, Donovan, et al. (1988) (Eds) *Scrutinising Science*.

[4] In for example articles in the *Journal of History of the Philosophy of Science*, in recent volumes.

procedures, such as logic and CCA, which might be disadvantageous. The word truth has some meaning. More than that, there are academic standards, rigorous standards, and rules and conventions, of the kind described by Popper.

There is perhaps something more, which however still stops rather short of providing a valid epistemological theory, or a specific scientific method, but which involves some understanding of elementary systems theory (as suggested by the example of the pendulum above). In view of the declared purpose of this study to help young students, discussion of epistemological issues has been avoided in the interest of arresting attention and sustaining interest. After all, it may be questioned how far hypotheses about scientific method are themselves falsifiable. It has however seemed reasonable to suggest that it is useful for students to be aware of the difference between falsifiable hypotheses and unfalsifiable conjectures, and that people do not pay good money for advice known to be out of date. One searches current dictionaries of philosophy in vain for an unimpeachable epistemology to meet the needs of the curious student. These needs are perhaps better met teaching students how to analyse a complex phenomenon into simpler ones, since no generally acceptable rules can be given.

It is now necessary to emphasise and restate what was discussed earlier. Much of what has been said may well be familiar to academic teachers, but in the work submitted by many students there is often little evidence of a grasp of critical conceptual analysis, or of systems analysis. This is not surprising, for secondary school teaching rarely involves specific critical conceptual analysis or even the recognition of various scientific procedures. Even at tertiary level it is not usual to find subject matter presented in a critical perspective. Not infrequently academic teachers present a subject in the perspective they were taught it.

The traditional teaching of Galileo's pendulum is an example of failure to stress teaching of system in this critical sense. Each swing in each direction is not regarded as the result of a transform, or change of state. Nor is the significance of the closed-single-valued system explained. As a result, Galileo's attitude to experiment is not understood. He was not trying to study cause and effect, any more than Newton was trying to explain gravitation, still less to apply a version of a scientific method along the lines suggested later by J.S.Mill. Galileo, like Newton, was trying to analyse a system, not only in order make predictions, but also to control it (as a physicians do when they prescribe a treatment).

To explain this, or any system, and thus to make predictions about it and, if need be, to control such systems, it is essential to identify the regularity of sequence of transformations (or interactions) within that system (which of course amounts to ensuring the system is closed). Once that regularity is perceived and analysed, then it becomes possible (within limits) to understand and make predictions about the system. That regularity itself is determined by variables, which, as it is a system, must by definition or observation be established. Any system may consist of an infinite number of variables - there is no theoretical limit to their number or complexity. Galileo was fortunate, in that the periodicity turned out to be isochronous, and did not vary (as the Aristotelian approach might have suggested) with the mass of the bob. In any physical system, the possible variables are unlimited - temperature, mass, density, time, electrical conductivity, chemical composition, crystalline structure, velocity, moisture film, radio-activity and so on. With biological systems - above all with the human species, variables are multiplied almost infinitely, and possible outcomes are consequently of course in terms of permutational, not combinatorial possibilities[1].

It is at present sufficient to point out that fundamentally the problem for the student is compounded by the student's lack of knowledge of systems analysis. This is certainly not to suggest that a place be found for systems analysis in the secondary or tertiary curriculum. But it is to suggest that some of the implications of systems analysis should be considered. Systems vary enormously, and so therefore does

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[1] This is made admirably clear in Ross Ashby (1956) *Cybernetics* pp.39-41.

the task of teaching and explaining them. The pendulum is less difficult to explain because what was involved was the basic single-valued closed system, in which Galileo was able to identify the essential variables governing the periodicity (gravity g and the length l of the pendulum) as eventually expressed in the well-known algorithm of Newtonian physics. At this point it is appropriate to return to consideration of CCA and systems analysis, in the form, it is suggested of elementary systematics.

§ 7: Explanation in terms of systems analysis

Research clearly precedes explanation, but the object of the research is to provide information to facilitate the explanation. The explanation of the solution of a problem may emerge from and include research, and thus involves initially analysis of the various procedures that may applicable, the course of which analysis is itself generally affected if not determined by the subject-matter of the problem - the systems involved, existing knowledge and the use made of it, and inspection of the relevant phenomena. In the previous chapter something was said of the implications of research and research procedures and some of the academic problems they present. It was suggested that the word 'research' applies to all the procedures used in the solution of academic problems - not only the larger scale research problems involved in formal theses for higher degrees, but also, perhaps on a reduced scale, to the equally rigorous procedures required in all academic work involving the attempted solution of problems and the presentation of an attempted explanation of the solution. Skill in justification is not the same activity as skill in explanation. Sometimes (but not always) a problem involves discovery - either an original discovery or the application of an already established discoveries, or of an established theory or belief. It is hoped that it has become increasingly clear that whatever scientific methods or academic explanations are used, the essential objective is to present a coherent, cogent and critical explanation, for the simple reason that the explanation must satisfy those to whom it is submitted. From the point of view of the student, the situation amounts to answering an examination question satisfactorily. In a wider sense, people will not always pay good money for out of date information.

Whether this will be easy or not clearly depends on the systems involved and how far students are familiar with and have identified and understood any procedures and systems and the techniques of explaining them, as they seem to be today. The objective is now an attempt to make specific some of the academic difficulties encountered in formulating statements and judgments that are regarded as academic knowledge.

This objective is likely to appear altogether too vague and theoretical. A more concrete and practical alternative is needed. It is not altogether easy to find an example that will clarify the point without embarking on distracting philosophic and other less relevant issues. Perhaps therefore an example may be appropriate - the practical alternative of considering Harris's thesis on the value of teaching grammar or 'parsing and analysis' in primary and secondary schools. On this subject Harris had, as a practising teacher, formed certain sceptical beliefs. What will now be considered is his attempt to explain and justify these beliefs.

This particular example is chosen partly because it is an instance of research based largely on statistical generalisation, a frequently-used research procedure which is open to CCA procedures.

§ 8: The Harris Experiment

During and after World War II there was a good deal of dissatisfaction with various aspects of primary and secondary school education, in England and the United States, which had been expressed in research by educational psychologists. An early example was the research by an American psychologist, Joseph M.Rice[1] who had questioned the effectiveness of time spent in American schools on learning

[1] Discussed in Ary, Jacobs and Razevieh (1990) *Introduction to Research in Education.*

spelling. He had attracted considerable attention with a study based on an extended experiment, which he relied on to justify his view. A similar experimental procedure was adopted by Harris. As an alternative to a long theoretical critical and methodological discussion, it is here intended to describe Harris's experiment in some detail. Then in chapters VIII and IX, it will be considered as an example of an attempt to justify certain beliefs. This will not involve an academic criticism of the merits of Harris's personal beliefs, but only of the effectiveness of his explanation.

Basically, this experiment was concerned with a comparison of two methods of teaching children to express themselves in writing in their native language. We are not concerned here with the merits and demerits of 'parsing and analysis' so much as the measure of success achieved in the research and possible solution of a problem in education. Whether or not the problem was in fact thereby solved - or even in fact whether any problem existed, is beside the point - that would be determined perhaps by others. The Harris thesis in its day was very highly esteemed as scientific and scholarly research, and was seen by some as affording sound justification for substantial educational reform. Was this assessment deserved, or was it in fact further evidence that, "in science, nothing is certain"?

§ 9 : The Harris Thesis - Approach and Structure

In 1962, P.H. Harris submitted as a thesis for the degree of Ph.D. at the University of London, a dissertation described as "an Experimental Enquiry into the Function and Value of Formal Grammar in the Teaching of English". For this purpose a fairly lengthy article by Dr Harris himself and published at the time, has been used as a source, together with a copy of the thesis itself[1]. From these sources, passages relevant to this discussion are reproduced in Appendix G, and referred to as (a), (b), (c), (d) and so on, in the text to follow. The reader is invited to consult this Appendix as necessary.

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[1] From a microfiche lent by the British Library.

The title itself gives some idea of the approach and structure. It is not apparently so much an investigation of a problem, with a proposed solution, as it is a description of an experiment which is intended to yield useful conclusions about the actual and potential results of the teaching of what is described as 'parsing and analysis' in English secondary schools. Harris does not specifically enunciate the precise problem that he proposed to investigate, but the first two paragraphs (a), (b), may be taken as implying his hypothesis. In the form of a question, it is "does the teaching of grammar (parsing and analysis) aid children's writing skills?" (d). It is fairly evident from the outset that prior investigation had somewhat inclined Harris to the view that the answer would be that it did not. Such a bias (if it existed) was not allowed to influence the commendable objectivity of the structure and administration of the experiment. Nevertheless, he does conclude his introductory account of previous research in the teaching of grammar in schools with the following comment, although it is not clear what evidence justifies his views about the circumstances that establish 'correctness' in writing English:

> It would appear that no grammatical picture, however exact and teachable, will be necessary to teach children to write correctly, since such correctness is established by the habit of imitation, by analogical extension, and errors are not felt as important unless either the break with convention offends a group in which the children wish to mix, or meaning is obscured. (Thesis, p. 97.)

It is appropriate that this assumption should be disposed of briefly, for it is not put forward as an assumption integral to his thesis. That could hardly be, for such an asumption would tend to vitiate his central thesis. In the context of Harris's thesis, it appears to be the conclusion Harris draws from a work[1] by a behaviourist psychologist, and all Harris. says is that it 'appears' to be the case. It is, in the context of the present study, perhaps sufficient to say that it is difficult to see what evidence might justify such a view. Its inclusion, however, emphasises again the need for CCA in the introduction of assumptions.

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[1] Fries (1957) *Structure of English.*

Before considering the actual experiment, there is first the formal *representation* of the precise problem to be investigated, and it is this step that Harris. seems not to have taken.

As mentioned earlier in another context, if a person is lost in the forest, his problem is not to find his home (he will recognise it when he sees it) but to find the path that leads to it. The distinction here is important for students to recognise, especially in the examination room. A typical example of 'representation' in this sense is the familiar 'nine points' problem[1], in which a diagram is presented consisting of an array of nine dots in a 3 x 3 square ; the problem being to connect all nine dots with four straight lines, without taking the pencil from the paper. Almost invariably, solvers assume that the lines must be contained within the square, although this is not given as a condition, and anyway this misrepresentation of the problem makes it insoluble. If it is assumed that the lines may extend beyond the boundary, there is little difficulty. It is perhaps the commonest of all mistakes in problem-solving to misrepresent the problem-space in this or in analogous ways. It has, for example, been claimed that "teaching students problem-solving will not improve their mathematical skills". But since mathematics surely involves skill in mathematical problem-solving, the claim quoted merely implies that the problem-space lies outside the area of the problem-solving syllabus, or that the teaching or methods adopted are deficient.

Closely related to the representation of the problem is its formulation, in the sense that Kant[2] uses the word in formulating the central problem of the *Critique of Pure Reason*. For Harris, as for all students, there are questions he has to ask himself before he begins to consider the answers he proposes to give to others. If for example, the question is as Harris states it - "does the teaching of grammar aid the children's writing skills?" Clearly, "yes" or "no" will be inadequate. How should the question then be formulated? Newton boldly produced a formula in

[1] Newell & Simon (1972) *Human Problem-Solving*, p.90. See also Appendix E.
[2] Kant (1929) *Critique of Pure Reason*, (translated by Kemp Smith), pp.45-50.

terms of a constant and two masses, and the distance between the masses. The answer, in this case should (if possible) be quantitative.

The question that Harris proposes to answer is much more difficult to answer satisfactorily than the problem confronting Newton, because the array of systems is infinitely more complex. As one writer[1] has suggested, a scientist should be only too delighted to consider a problem such as Newton's, involving only 'summed pair' interactions in systems - something like a 'transformation' in systematics, as mentioned above.

But even if satisfactory measures of these interactions are devised, these alone do not necessarily justify a decision. If, for example, appropriate tests of a certain class in a school were to disclose that the mathematical skills of its members are steadily deteriorating relative to comparable classes in the same school, then decisions may well have to be made - but what decisions? A satisfactory answer will require a thorough assessment of the whole system - the fault may lie in the behaviour of the teacher, or in the text-book, or a troublesome group in the class, or a plurality of factors. The operational characteristics of the systems involved need first to be understood. What all this amounts is that the whole structure of the constituents of problems involving the human brain, especially when interacting with other sets (like classes being taught in schools) of human brains is so infinitely complex that without very detailed research and prior assessment of these complexities, a satisfying answer is impossible unless preceded by precisely worded and considered questions.

The Harris thesis is open to criticism on such grounds. The problem area was seen by Harris as a decision problem: "Is the teaching of English, or more specifically the teaching of written English to a certain standard, helped by grammar lessons?". This is recognised in the passage from page 97 of Harris's Thesis quoted above.

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[1] Weinberg (see Klir (1972)) *Trends in General Systems Theory*, p.103.

On the other hand, as comparatively few secondary school children need to develop such academic literary skills, Harris's research activity might have been more profitably devoted to pursuing investigations suggested in Appendix 4 and elsewhere in Harris's Thesis. This is however to suggest a research of a very different kind, and while to make such a suggestion is hardly relevant to Harris's thesis, it obviously does have some relevance to this study, especially on the matter of research methods in the justification of beliefs. Of more relevance in this respect is the scale and scope and the whole approach to the research and the experiment, about which something must now be said.

First, it should be noted that at the time Harris's Thesis made a very considerable impression among those interested in the teaching of English both in U.K, in the British Commonwealth and in the United States, especially in the matter of the teaching of formal English grammar in schools. Harris follows tradition in such theses by beginning with an account of earlier research (1890-1960) in the general field. The merits of teaching grammar had long been questioned - long before 1890 - amid profound changes, political and social that had taken place in the whole problem-space. For one thing, the English language had since about 1890 become increasingly established as easily the most used language for international communications. Furthermore, because it is so widely spoken and read and hence extensively taught, there had developed a demand for teachers of English, and hence for an understanding of English grammar. The result is that while in some areas the teaching of grammar in schools declined, at the same time the practical value of some awareness of grammatical structure has tended to counter the influence of the anti-grammarians, and to this modern academic interest in linguistic analysis has added further weight. In addition, as mentioned above, the mastery of a language for academic purposes, at least to some degree, had been a tradition for centuries even to the time of Newton, and it was largely for this purpose that grammar was taught in grammar schools from Latinate grammar text-books. Harris seems not altogether to take account of these factors, in narrowing the scope of his research of earlier teaching of grammar to the period subsequent to 1890, and in addition seems to have failed adequately to assess precisely how effective the teachers of grammar used in the experiment actually were. Most of the teaching of grammar in England before 1890, it seems, was not in Government schools, but in the more expensive independent *primary* schools, and was chiefly intended as an aid to learning classical languages. In NSW, for example, enquiry suggests that before the 1920s the teaching of formal grammar was confined, as in England, in the state system to primary schools. The writer has been at pains to consult a retired 86 year-old Australian teacher who confirms that at a state primary school as a child he was taught formal grammar by well-trained teachers, using exercises in the construction of paragraphs and sentences to specific patterns - e.g. "Construct a paragraph of three compound sentences, each consisting of one principal (main) clause, and at least one other main clause, and two subordinate clauses. Examples of prepositional and adverbial phrases should be included." By the time the informant had became a teacher of secondary English, 'parsing and analysis' was no longer taught, though Latin prose composition of a standard presupposing ability in 'parsing and analysis' was virtually compulsory for university (Arts) entrance. In England by the 1950s, in the writer's experience, teachers of 'parsing and analysis', trained to teach above a very elementary level, were rapidly becoming an endangered species. By the late 1950s, Nesfield's English grammar textbook seems to have been out of print in England. It is thus permissible to ask how well qualified the teachers were in Harris's experiment.

This somewhat detailed digression is not of course intended as a contribution to a particular educational controversy, but as indication to readers as to the standards of grammar teaching then apparently aimed at, for in this respect the Harris experiment has much to say. Harris relies on the class test-books then in current use, to give an idea of what was in fact taught. In its own day, the Harris Thesis was rightly commended[1] as an example of what an enthusiastic practising

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[1] Watson (1981) *English Teaching in Perspective*, Ch XV.

teacher might achieve by planning, organising and conducting his own research in current teaching.

The relevance of all this to the present study is the importance of a thorough research of the whole relevant problem-space, and careful consideration of the systems involved. Harris. makes careful use of the statistical methods available to him, and has little difficulty in confirming the low statistical correlations already established in earlier studies,[1] although Harris's experiment was on a larger scale. But the point is, what was the reason for this low correlation - not higher than + 0.3?

Many reasons might be suggested for a correlation score so low as to suggest that 'grammar' lessons had virtually no effect at all. But if questions had been asked about the systems involved, perhaps some possible answers might have emerged. Highly complex systems are involved, systems which proliferate variables in millions, which are far beyond the simple model of statistical generalisation that Harris relies on, assuming a model along the lines of those indicated in a typical modern educational research text-book. This typical book, for example suggests that some unspecified statistical 'breakthrough' enabled the social scientist to multiply variables, and seems to assume Bayes's postulate is provable, which is perhaps justified only when the many variables can either be identified, or when a simpler model can be devised which will accommodate them. Modern students seem often to believe that 'research' in the behavioural sciences has by some statistical technique now achieved the status of being able to generate 'scientific law' - indeed, the phrase "the latest research" is commonly heard as justifying even unfalsifiable hypotheses.

It is relevant here to emphasise that in Harris's thesis, the teacher is one of the most variable elements in the system. For reasons not made explicit, Harris decided that a longer period and a larger population than used in earlier experiments

[1] Harris Thesis, pp.196-200; see also *Use of English* article in Appendix G.

was generally preferable. This is surely not necessarily the case as such an extension may multiply variables. It may be more important to frame a hypothesis that is more specifically falsifiable. Here, however, difficulty may be expected.

The reason for difficulty in research of this kind may become apparent if the analogy of an operational research in production efficiency is considered. Suppose it is a matter of assessing desired output against input. As has already been mentioned, in industry, for example, the desired output may be assessed and maintained by various techniques of quality control. Random samples are taken and tested by criteria appropriate to the desired grade of output to maximise profits (or whatever the goal of the firm may be over the agreed time-span). This is a relatively simple matter, for the two main reasons discussed above in the context of Operational Research. First, most of the variables are measurable; and secondly, the systems are fairly stable single-valued closed systems of variables. Furthermore, in modern management techniques there are available reasonably effective means of operational control systems.

Harris however was faced with certain difficulties of which he seems not always to be fully aware. Certain significant inputs and outputs were for the most part not measurable, and were widely variable (as in most behavioural science situations); for example, the units of input and output (by teachers and by students) who are themselves probably the most complex of all systems. Many teachers have subjective attitudes in some degree towards the subjects they teach, as frequently have their pupils, their parents and prospective employers, the media, and society at large.

To pursue the analogy of quality-control methods in an industrial organisation, the problem confronting Harris here is analogous to assessing the efficiency of a particular procedure (the teaching of parsing and analysis) in terms of its contribution to output. In a reasonably efficient industrial organisation, it will not be difficult - indeed it is done every day in cost / benefit analysis - to calculate the net cost of the investment in relation to the net benefit of its output, and hence, as a routine accounting procedure, to decide whether the capital cost represents a justifiable expenditure of available funds. To Harris the analogous problem is almost insuperable, because of the variety and systematic structure of the variables. He seems to have been aware that the main problems (granting the procedures he adopted) lay in devising the random samples on the outcome of which the test of his hypothesis depended.

The actual tests are described [appendix G (c), (d)]. The test procedure described thus provides what Harris calls "ten important scores reaching significance in a reliable measure". From these scores, Harris states that "it seems safe to infer that the study of English grammatical terminology had a negligible or even a relatively harmful effect upon the correctness of children's writing" at that educational level.

It is not relevant at this point to attempt an academic assessment of the experiment described, or its relation to the conclusion reached. What is relevant is to consider how far Harris has satisfactorily explained his beliefs. In this connection it is historically interesting and relevant to observe that in fact Harris's Thesis attracted a great deal of attention in England, in the United States and elsewhere; (whether as a result or not, it is impossible to say, but educational authorities in many English speaking areas decided to discourage, and in some cases, even to forbid the teaching of formal grammar in secondary schools). Of course Harris can in no way be held responsible for the decisions made by others who may have been influenced by the findings in his Thesis.

Harris's findings are however largely attributed by him to his use of sampling techniques. These findings should now be specifically stated, for it is often here that the logical 'uncertainty', at least in social sciences, arises, and it is this aspect of the Harris experiment that is specially relevant to this study, and which as such will be discussed in the following chapter.

The concluding paragraphs of Harris's Thesis (pp. 208-209) given *verbatim* are as follows :-

> Thus all that may be said with safety is that in five varied schools a form was taught formal grammar for two years, and fairly successfully. Yet in no school and in no measurement did the essay writing of these forms shew any significant superiority in terms of the selected criteria over that form whose grammar lesson had been replaced by one giving direct practice in writing English. To say this is perhaps to say enough. That significant gains were made by the non-grammar forms is less to the point here, but that such gains commonly existed need cause very little surprise when one considers that an extra writing period in place of grammar must in fact probably (*sic*) double the time given each week to actual written work in class. It seems safe to infer that the study of English grammatical terminology had a negligible or even a relatively harmful effect upon the children's writing in the early part of the five Secondary Schools.

Such a conclusion is reinforced by one further point, mentioned in Chapter 1 of the Harris's own appended article. This was that no high degree of correlation was found to exist between the marks gained by two hundred and eighty five G.C.E. candidates for their answers to the grammar question in the examination and their marks for the other parts of the paper - essay writing, précis, and comprehension. The correlation co-efficient will be recalled as being + 0.365 +/- 0.022.

Such is the broad outline of the Harris experiment, together with a few general comments, in order to provide contextual perspective. In the next chapter it will be considered in more critical detail as an attempt to justify a belief.

CHAPTER IX : EXPLANATION AND THE JUSTIFICATION OF BELIEFS

The previous chapter ended with the conclusions that Harris drew from his experiment over thirty years ago, and the intention is now to consider the Harris experiment as an example of educational research intended to explain and to justify the beliefs that Harris had formed, as stated in his thesis, and quoted *verbatim* at the end of Chapter VIII above.

The Harris thesis is here intended as an example of a frequent procedure in educational research of presenting what are perceived as in a way that is intended to be effectively and convincingly understood by those being addressed. Words like 'beliefs[1]' are preferred to words like 'concepts' and 'hypotheses' as being more easily understood, and more appropriate to an interdisciplinary context. Therefore, what is relevant here is how to decide whether a particular attempt at a particular time to explain and justify particular beliefs is successful or not.

A student begins his university studies with various degrees of beliefs, some framed about what Kant calls concepts (see Introduction to Part IV) Other beliefs relate to all sorts of things. In the pursuit of knowledge, some of these beliefs will be clarified, (perhaps along the lines Kant suggests), others may be modified, others again abandoned, and, especially in the student's chosen studies, new ones added. These latter beliefs are more particularly relevant to the present context.

The Harris thesis referred to in the previous chapter is an instance of a process by which such beliefs may be changed into what is perceived as useful

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[1] Justifiable Problem Solving Beliefs; there is no certainty in the academic world except within a closed axiomatic system, but there are beliefs which are justified to the extent that reasons are produced that they solve problems and make predictions. See also Chapter X (the word 'justification' is not here used in the purely epistemological sense, and its philosophical implications are not discussed).

knowledge in, perhaps, decision making. It will be suggested later that the proceedure was flawed.

Since Harris wrote this thesis many years ago, much has happened, politically as well as socially, including a period in which the teaching of parsing and analysis to improve English virtually ceased. More recently it has been largely restored, sometimes on the ground that it aids TESOL teaching.

First, there are two general aspects of Harris's experiment, relating to scientific attempts to justify beliefs, that need to be considered. First, there is the matter of the identification of the problem to be investigated; secondly, there is the basic means of justification adopted - statistical generalisation on the basis of random sampling. Although Harris's Dissertation was widely approved[1] at the time it was submitted, and it was credited with having had considerable effect in bringing about certain changes, it has in since then been the subject of criticism from various educational institutions, but not of a kind relevant here. The first matter is therefore the identification of the problem to be investigated.

§ 1: The Identification of the Problem

Harris identified the problem as one of 'ends and means' - did teaching grammar improve English composition or did it not? Harris believed that he had produced conclusive evidence that it did not[2]. But was this really the problem? The improvement of English composition was the problem for the teachers. Partly as a result of Harris's experiment the teaching of parsing and analysis in schools ceased in many schools. Thus it seems that the problem had been wrongly identified, and action taken may still have left the real problem unsolved.

It is moreover of great help in the identification of a problem, as mentioned above[3] in relation to the development of language, to set the problem in its

[1] See Watson (1981) *English Teaching in Perspective*, p.133.
[2] For his conclusion see passage quoted at end of previous chapter.
[3] See above Chapter I, §2.

historical background. Had Harris done so, he would have realised that parsing and analysis had been taught for centuries as a means of improving written and spoken communication in natural languages, and indeed was, as previously mentioned, originally devised by Alexandrian grammarians for that purpose, long before the advent of institutionalised education, in the early centuries AD. Though demotic forms of Greek and Latin were widely spoken in the ancient Mediterranean world, there was then an increasing need for an academic language with strict and recognised standards and conventions of correctness, especially in great academic centres like Alexandria, Rome, Constantinople and Athens itself. This need was perhaps accentuated by the increasing migrations from the East who did not speak European but Indo-Aryan native languages. These immigrants needed (over the medieval centuries) to acquire the natural languages of the European culture. In short, in the case of English it amounted to the teaching of traditional functional English grammar using Latinate grammars. This had historic consequences when education was at first largely domestic, and later tutorial, finally becoming institutionalised partly as a result of the invention of the printed book and the consequent demand for tuition to the point that literacy became almost a social obligation, and hence a social institution The point here is that grammar in this sense became a basic study not only in English grammar schools, but also in the schools of most European countries as part of institutionalised education. Moreover, in medieval England primary education, was in 'dame' schools, and secondary (classical) education, had, as one of its main functions, the training of 'clerks in holy orders' to serve the Church. After the Reformation the monarchy set up grammar schools (to replace the Catholic priests with secular teachers) for the education of the 'more able' boys. Thus it was eventually seen as desirable that the primary schoolchild should be taught some grammar, so that the child fortunate enough to secure a place in a grammar school (where Latin was taught) might not be too greatly disadvantaged. In short, grammar was originally taught in primary schools in England, not to improve the child's written English, but to improve the child's ability to learn a classical education. The implication of this historical perspective perhaps led to Harris's somewhat restricted view of the problem-space.

The implications of this, as far as the Harris thesis is concerned are thus fairly obvious. It seems that in the event, Harris's thesis may have played some part in substantially reducing the amount of parsing and analysis taught in English-speaking schools. Now familiarity with the terminology of parsing and analysis is now often regarded as essential in TESOL schools worldwide, especially where a second language is usually required for academic purposes; in addition, the English language has become the most widely used of all languages, leading to a revival of parsing and analysis. Other implications of the institutionalisation of education are often relevant in educational research, but these are not relevant at the moment, but had H. considered the system involved, his investigation might have been more fully analysed in terms of the systems involved.

Problems, in systems analysis, are identified in terms of their interactions with other elements in the relevant system, and the fewer the interactions, the more general will be the problem; the greater the number of interactions, the more specific will the identification of the problem need to be, and the greater the variety. In this case, the problem space is an area in institutionalised education, and the wording of the problem should thus be specific at least as to age, curriculum, content, method and objective. All this, and a good deal more, is implied by the characteristic of the problem space as 'institutionalised education'. A less specific and hence more general wording of the Harris's problem might be "does teaching children grammar improve their written natural language skills?" This however may identify a very different problem. It may reduce to a little child and the child's parents, or the child and a highly skilled tutor. If the problem space is duly considered, then the variety of the problem becomes apparent, for 'teaching parsing and analysis' in institutionalised education implies 'teaching the child as a member of a constrained group of peers, by a teacher trained in a certain way, with a certain freedom of action, subject to certain constraints' - and so on. There are, and have historically been, many other systems of education in various other societies, but practically all modern educational research assumes the institutional problem space, although there is evidence to suggest that the institution is not invariably successful in providing its society with a fully employable population.

The result of narrowing the problem to its parochial boundaries is that Harris tends to overlook, in addition, some of the interactions of the elements of the systems involved. First, the real problem is presumably that of discovering a means of successfully teaching English composition, rather than one of exhausting the variety of elements that cause failure of the means - such as teaching methods, subject matter, skills of pupils and/or teachers. Harris is aware of this, and suggests some possible alternative means. Secondly, it is clear that if his investigation is perceived as establishing that teaching parsing and analysis does not serve its intended purpose, the basic problem of teaching English composition still remains.

It is not appropriate to pursue this systems analysis any further here, but such analysis of problem space shews how it may stimulate alternative possibilities. The next consideration is the means that Harris has chosen to justify and explain the conclusions that he reaches. The method selected was statistical generalisation on the basis of random sampling.

§ 2: Means of Justification

Having identified the problem, it is now appropriate to consider the form of Harris's justification of his rejection of grammar by statistical generalisation by sampling. There are other methods. For example, Newton set out to explain certain conclusions that he, with Kepler, had reached about the Solar system and the motion of the planets. The method (very different from that of Galileo) Newton chose was to explain the 'natural laws' in terms of mathematical principles, or *Principia Mathematica.* This explanation eventually proved successful, but his reasoning was not fully understood until some decades later, and its implications until two centuries later. Newton admitted that his novel mathematical use of 'fluxions' (the calculus) made this delay inevitable. Nevertheless, the immense scope of his achievement and the mathematical and logical rigour of his reasoning was ultimately triumphant. As a modern writer[1] has said, "it is a great pity Newton is so little read, especially in an age which prides itself on being scientifically-minded, for nothing is less scientific than to overlook the fact that present ideas have past antecedents."

The means chosen by Harris followed the early twentieth century practice of statistical generalisation supported by experimental random sampling. However, by representing the problem as he does, and by producing the experimental conditions he describes, Harris evokes Popper's ironic remark[2] "if you seek corroboration, you will always find it". So Harris, by representing the problem as he does, and by producing evidence under the specified experimental conditions he had set up, does no more than attempt the task of demonstrating that the teaching activity in this experiment failed to achieve its objective.

What is relevant here is a closer look at the actual investigation implemented by Harris, and the specific line he chose to explain his views. The criticism of the experimental demonstration (as it is proposed to present it here) falls into two parts, the logical and the procedural. The formal logical criticisms of the use of the method chosen by Harris are in a sense traditional, and may be found expressed in many modern text books of logic[3] and of the philosophy of science, and can be dealt with quite briefly. The actual procedure selected by Harris, statistical generalisation based on random sampling, is still frequently used in educational research, and is somewhat similar to the industrial quality control method in industry already mentioned. It has, however, since the mid-sixties come under heavy criticism from the Popperians[4], as well as certain of the Kuhnians[5], and

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[1] Thayer (1953) *Newton's Philosophy of Nature*, p.vii.
[2] Popper (1968) *Logic of Scientific Discovery*, p.252.
[3] For example, Kehane (1973) *Logic and Philosophy*, pp.290-296.
[4] Who prefer Popper's 'falsification' criteria: Popper (19 *Logic of Scientific Discovery*, pp.30- 45. and Cohen & Hesse (1980) paper No 6 on Statistical Hypotheses.
[5] Donovan et al. (Eds.) (1988) *Scrutinising Science*, p.15.

those who condemn such statistical generalisations as attempts made to 'dress-up' an invalid induction' as valid deduction[1].

It is not possible to detail the very considerable literature relating both to the epistemological and theoretical aspects of the issues involved. The references given in the paragraph immediately represent only a very small part of the material available, most of which is quite inappropriate in a study relating to students beginning their first semester. It is however disturbing to find teachers still giving lectures on what they describe as 'scientific method,' oblivious of the situation to which Larry Laudan drew attention over a decade ago[2].

> The theory of scientific methodology ('methodology' for short) appears to have fallen on hard times. Where methodology once enjoyed pride of place among philosophers of science, many are now sceptical about its prospects. Feyerabend claims to have shown that every method is as good (and thus as bad) as every other; Kuhn insists that methodological standards are too vague ever to determine choice between rival theories. Popper generally treats methodological rules as conventions, between which no rational choice can be made. Lakatos goes so far as to assert that the methodologist is in no position to give warranted advice to contemporary scientists about which theories to reject or accept, thereby robbing methodology of any prescriptive force. Quine, Putnam, Hacking and Rorty, for different reasons, hold that the best we can do is to describe the methods used by natural scientists, since there is no room for a normative methodology which is prescriptive in character. To cap things off, everyone in the field is mindful of the fact that the two most influential programs in 20th century epistemology, associated with the inductivists and the Popperians respectively, have run into technical difficulties which seem beyond their resources to surmount.

Laudan goes on to explain that the 'historicists' like Kuhn and Toulmin have inflicted the cruellest wounds on methodology. But it was Carnap[3] who, in 1958, claimed there is no one scientific method. That would require a special framework and a meta-language, which of course places the matter well outside the needs of first-semester university students, and perhaps at this point justifies committal of this epistemological issue to the 'too difficult' tray, in favour of the more relevant approach of CCA and systems analysis.

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[1] Strawson, (1952) *Intro duction to Logical Theory*, pp.252-263.
[2] In the *American Philosophic Quarterly*; Vol. 24, No 1, 1987, p.19.
[3] Carnap (1950) Empiricism, Semantics and Ontology, *Revue Internationale de Philosophie*, Vol 4, pp.20-40. Also reprinted in Carnap (1956) *Empiricism, Semantics and Ontology* (2nd edn.) pp. 205-221.

It would certainly seem that the task was rather more formidable than H had anticipated, for he seems to have reasoned that the italicised proposition: *If children are taught formal grammar, then their English composition is improved* is refuted, if the consequent is falsified by producing instances of experimental random sample statistical generalisation. It is not as simple as that, for in the first place, as explained above, a disconfirming case for a statistical hypothesis in general does not *falsify* that hypothesis; in the second, there may be far too many variables involved.

For one, there is the standard of teaching and the methods used, the attitude of those individuals teaching, and those being taught. In short, in terms of systematics there is the formidable variety in the systems involved. Moreover, the assumption that bad written English becomes good written English if the composition is grammatically correct, is convincing only if the grammar is in fact linguistically sound - that is, the grammatical rules are in fact correct. (Certain schools of modern linguists might well reject the grammar taught in Harris's day, in favour of their own approach.) But we accept that these are the terms of the criteria selected in the experiment. But in terms of systematics, the transformations in the systems involved are neither closed nor single-valued, and hence no conceivable experimental method could yield predictable outcomes. In other words, there is such a thing as plurality of causes.

In what way is this so? According to the definitions of 'closure' and 'single-valued' as explained above[1], there are so many possible transforms as to make rational prediction impossible. This may well prompt the objection that surely some empirical testing is better than unsubstantiated opinion; that surely a medical practitioner, for example, is right in referring to statistical clinical tests of possible treatments, and is making a rational decision (in the absence of other evidence) in preferring the treatment with the most favourable statistical result. But the two cases differ when analysed as systems.

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[1] Chapter VIII §4.

There is first the relatively simple case of the clinical test of a single drug or treatment of a specific condition, as against the infinite variety of a class of individuals over a lengthy period. Second, the answer here is that the implication of the phrase "in the absence of other evidence" is that the decision depends only on the weight of evidence, and on no other factors. If that is so, then the weight to be attached to specific evidence often depends on the person responsible for making the final decision - in the case of the clinical decision, it is usually the patient, if in a condition to decide. But in decision-making in real life there are frequently many factors that determine decisions, including the personal and subjective. Harris himself in the text mentions several other factors.

There are in fact a number of factors of greater relevance to this study that have to be considered other than the matter of the plurality of causes suggested by the many variables. The issue *in this case* is whether the evidence *as presented* by Harris justifies the belief that the teaching of grammar in the sense described does not improve the writing of English compositions by the criteria used by Harris. Harris is clearly of the opinion that his belief (that it does not improve children's written English) is supported by the evidence he considers, while it is suggested in the present study, that the evidence is not only inadequate, but that it is doubtful whether any method in such circumstances could produce conclusive evidence, for the reason that the variety in the systems involved precludes that possibility.

The result, in short, is that Harris's experiment cannot be said to do more than raise doubts, for it deals only with one experiment, however elaborate and painstaking. It still does not demonstrate, and cannot demonstrate, that teaching parsing and analysis to 14 year-old children does not *in general* improve their writing skills, because there are too many variable factors in the systemic structure, for example, of institutionalised education, of which Harris's procedure does not take account. That criticism applies very often to the application of statistical generalisation procedures under the conditions of institutionalised education.

From the above, it is maintained here that in considering any such problem, students should be aware of the need to analyse and then synthesise that problem in terms of systems. Even the very sketchy outline of systems theory given above should be enough to suggest to students the need for such an approach, just as it was earlier suggested that Newton's achievement in *Principia Mathematica* was his analysis of the *system*, of the Solar system. In the matter of Harris's thesis, it is contended that such an analysis of the problem might well have revealed its great complexity.

While this is not a text-book of GST, it is perhaps possible to justify such an approach in sufficiently elementary terms to serve the purposes of this study, and indicate the value to university students of even a very rudimentary grasp of GST, which might be called 'systematics'. Such a study forfeits any claim to be an 'epistemology' because of the assumptions and stipulative definitions introduced.

§ 3: A Simplified Systems Theory Analysis of the Harris Thesis.

It was suggested in §4 of the previous chapter, that Harris's attempt to justify a belief that "the teaching of parsing and analysis would not effectively improve children's written English," by means of statistical generalisation based on random sampling, could not be expected to succeed. One reason for this is that the system involved classes of children being taught grammar by a teacher, within the larger system of institutionalised education. All this involves systems that are neither closed nor single-valued, and are therefore not determinate. That is to say, if we regard the teacher's instructions as the operand, the resulting transforms cannot be said to be 'closed' - in some cases, a child's written composition is judged to have improved, in some cases it has not 'significantly' improved, in yet other cases, it is judged even to have deteriorated. The transform, in short, cannot be identified and predicted. Nor is the transformation single-valued. All teaching is variable in its effect as an operand - what works well with one child may not produce the same transform with another child. Above all, propositions involving any element of probability cannot yield valid deductive conclusions.

From this it is clear that the analogy mentioned above of the clinical random sampling statistical analysis is false. The operand, the treatment, (say, a course of drugs) is constant, as the transform is no doubt identifiable as successful or as unsuccessful - if there is doubt, then of course the method must be judged as inappropriate, on the ground that the transformation is not single-valued.

This systems approach may be met with the criticism that it is too absolute, that the findings (like those in the case of Harris) may be *qualified* by analysis, if not quantified, so as to give them at least some practical value as a guide to educational practice. This may well be the case, but even so, the systematics approach indicates something of the direction that such a qualitative analysis might take as a means of explanation, and thus might give an explanation added value.

The systems theory approach has other values, which may certainly have educational significance. As von Bertalanffy (a biologist) has pointed out[1], many open systems, in contrast to closed systems, exhibit a principle of equifinality, that is, a tendency to achieve a final state relatively independently of initial conditions. They tend, in the presence of 'perturbations' that take them away from their normal state, to return to their steady state. In a word, they exhibit *homeostasis*. (but, it might be noted in parenthesis, in the open systems of games of chance, long runs of favourable outcomes *tend* not to occur - but this does not mean that they *do not* occur.) This tendency is to be found not only in certain biological conditions, but also in certain human institutions as well - such as industrial and commercial firms, educational institutions, and even human families. Of course, Harris might well claim (prompted by GST) that homeostasis in educational situations may justify his case. But. if so, that claim would need qualitative analysis in his explanation to support it. Homeostasis has not been shown to be a necessary characteristic of all

[1] Von Bertalanffy (1956) *General System Theory*, Reprinted in *GS Yearbook* Vol 1, pp.1-10.

open systems - only certain biological cases[1]. In any event, Harris does not appear to be aware of the concept of homeostasis in this context. The late Karl Popper might be expected to concur with this criticism of Bertalanffy's concept of equifinality.

Finally, it is certainly not the purpose of this section in any sense to refute Harris's thesis or to discredit his beliefs about the value of the teaching of 'parsing and analysis'. All that might be claimed is that, as it stands, the effectiveness of the explanation is diminished, and perhaps the Thesis would be likely to satisfy only those who were already doubtful of the value of teaching grammar to young children to improve their written English, while as an example of an academic explanation justifying the stated beliefs, it may be somewhat flawed. For reasons already discussed, the use of statistical generalisation by random sampling is not generally regarded as satisfactory, not only on logical grounds, but on the grounds of systems synthesis.

One reason for its rejection, is the *second* of the two matters mentioned just above - the defect of the means often used to justify such beliefs - in this case statistical generalisation. This second matter, the highly controversial issue of the old 'scientific method' of justifying such beliefs, deserves special emphasis to be given to it here, and in the final chapter.

§ 4: The Use of Random Sampling Techniques

In the behavioural sciences, and in educational research like that of Harris in particular, the method of statistical generalisations based on random sampling is frequently used. Depending on the set-up of the experiment, the argument is then in the form of "only x percent of the tested random sample of students profited by this method of teaching, therefore only a minority (y percent) of all students will profit by this method of teaching." The reasoning is thus (according to some logicians) inductive, and (according to others) an attempt to make an inductive

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[1] Rapaport's discussion, Klir (1972) *Trends in General Systems Theory*, p.53-60.

argument appear deductive, or perhaps just an attempt to justify induction, or merely to influence opinion in the direction of a particular conclusion. At least, from the point of view of the academic teachers and their students, the issue is certainly controversial. The point is carefully argued by Hesse and others[1] in a fairly recent conference at Oxford, as it has been at other earlier conferences elsewhere. Certainly those participating seem to agree witth Fisher[2] that the statistics themselves, as well the investigator, influence the chosen design of such experiments. More significant still is the purpose of the investigation. As pointed out above, 'welcome' information should be distinguished from 'unwelcome' when decisions have to be made. The stock case of smoking and lung-cancer is a case in point. The significance of information that *x* percent of adult Australians who smoke more than a packet of cigarettes a day will contract lung cancer before they are 60 depends on very many factors other than the version of probability calculus selected, or the size of the sample. Thus when statistical generalisation of any kind is used, especially in application to educational research, there are so many systems to be taken into account that predictions of any value in making decisions or in controlling systems are almost impossible to achieve. The result[3] is that "the social sciences today possess no wide-ranging systems of explanations judged as adequate by a majority of professionally qualified students, and they are characterised by serious disagreements on methodological as well as substantive questions." This means that in such sciences, their human practitioners constantly find themselves confronted with overwhelming complexities and difficulties. This seems especially so with psychology and medicine, and as has been shewn the difficulties are compounded by controversies over methods and approach. This makes CCA and systems analysis all the more relevant. No agreed methodology, and the fact that both sciences are confronted with very large numbers of very small

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1 Cohen & Hesse (1980) *Applications of Inductive Logic*, pp.68-89, paper by R.D Rosencrantz

2 Fisher (1979) *Statistical Methods for Research Workers*, pp.9. Fisher excuses himself "from entering the subtilties of prelonged controversy" and affirms that inverse probability is "founded on error".

3 Quotation is from Nagel (1961) *The Structure of Science*, p.449)

systems of virtually inaccessible systems of cells, means that progress in knowledge is disappointingly slow. This leads to a kind of siege-mentality among practitioners, and a sensitivity to a criticism, and hence to what is seen as hostile CCA which further retards advance. These observations are however mere generalities When, for example the highly critical 'historicist' approach of Kuhn and others question the validity of the notion of a single scientific method or the validity in some cases of statistical generalisation, this is perhaps seen as threatening the only means of securing advances in knowledge. There are however signs of advance nevertheless, in, for example, the work of the Churchlands in neurophilosophy, and of Marr in his book *Vision*, in which he suggests that concepts should be developed in terms of computational models of neuronal systems. This involves skills in the higher mathematics of the tensor calculus and Gossan mathematical logic and perhaps eventually to systematics.

More important, it should be noted that Harris's research, like many educational researches, as suggested earlier, might have been treated as falling into the category of what Rosenkrantz[1] calls a 'decision' problem; the decision, or special case of 'partition' problem perhaps being whether to teach 'parsing and analysis' to ensure that children were taught to write correctly, or to give up smoking. Harris's claimed objective was simply to test the belief that teaching children to expose teaching grammar as a waste of time. Harris does consider other possible benefits that might accrue from a discipline involving analysis and study of structure, or as a useful exercise in language skills and accurate expression. But they do not appear to be adequately considered in the research. It followed closely the model of Price[2], the celebrated pioneer of educational research by statistical sampling, mentioned above, who had questioned the teaching of spelling in USA schools. Policy decisions were made, and in some cases the time spent in teaching formal grammar in primary and secondary schools was reduced and sometimes such teaching forbidden. Since then however the increased demand for TESOL for

[1] Cohen & Hesse (1980) *Applications of Inductive Logic*, pp.68 et seq.
[2] Not to be confused with the Price who was a friend of Bayes.

teaching other than native languages may have led to something of a revival in teaching English grammar. Decision problems in a certain sense are especially significant in institutionalised education, as the decision may be influenced by factors other than purely educational - trades unions, politicians, even the local economy.

Nor, on the other hand, was Harris attempting to justify or explain a theory about the teaching or learning of a language to academic standards and for academic purposes. It is relevant later in the course of this chapter to digress briefly to point out that the research and explanation of theories is in any event rather a different matter. This is so because there may be insufficient grounds for regarding particular beliefs or theories as paradigms for partition analysis.

In practice, whether it is a theory or hypothesis that is being investigated (as in the case of the Harris experiment) it is essential to see the problem in its operational perspective in a real and practical way. Otherwise problems tend to be oversimplified, for each problem is likely to have its own innate difficulties, and hence each problem in a sense may have its own unique solution, and would-be solvers, in submitting their solutions, often make implicit and unspecified assumptions. Students may be well advised to consider the implication of these essential factors in their own studies. As has already been mentioned, the solution of any scientific problem, whether in the form of an answer to an examination question, an assignment, an essay or A thesis, is essentially an explanation within a relevant framework. It was failure to appreciate the operational perspective, that has perhaps led Harris to perceive the problem as simpler than in fact it was. To take an extreme case, suppose some educational eccentric were to maintain that teaching primary-school children the elementary arithmetical operations of addition, subtraction, multiplication and division, was of no value in training them to give the right change when shopping, it would surely require more than random sampling to support the thesis.

The basic purpose of introducing the Harris experiment into this study is as an examplar for students to assess the merits of a thoroughly academic attempt to explain and to justify certain beliefs relative to a certain educational problem. We are here concerned not with the beliefs themselves, but only with the methods of research and explanation used to justify them, and in particular with the extent to which the explanation has clearly been planned to be fully 'operational' in the sense that the research has been structured to ensure that a clear explanation emerges taking appropriate account of the systematic complexities involved. The explanation in short has to provide a specific answer to a specific question. It would seem to be a fair judgment of the Harris treatment that he allowed the problem of providing statistical experimental measurements and statistical generalisations to obscure what might be more important operational considerations. It was partly for these 'operational' considerations that the Harris experiment was chosen as an example.

The concept 'operational' in GST involves envisaging all attendant circumstances, all practical real-life considerations. It may be helpful to explain the meaning of 'operational' when applied to research, as it may be a concept of considerable value to the modern university student. More however will be said of this operational research when the Harris Thesis is considered in rather more detail, in what here follows.

§ 5: The Lessons of the Harris Experiment

What the above discussion amounts to is that the Harris thesis is built around an exceptionally painstaking experiment using statistical generalisation based on random sampling, to provide evidence that teaching parsing to fourteen year old children did not improve their English writing skills. The procedure, it was suggested, is not only open to certain specific objections as to its logical validity, but it seems further weakened by inadequate appreciation of the constraints revealed by conceptual and systematic analysis - constraints due to the kind of decisions involved and the nature of modern institutionalised education. These are aspects that may well affect the value of the explanation that Harris offers in justification of his beliefs.

As has been suggested above, the answer to this question (at least for high-school students and their teachers) is not really to be found by finding a definitive answer to the problem of induction, but in the researcher's success in explaining the conclusions reached, the problems and difficulties encountered on the way, and any means used to overcome them. The researcher must begin by asking himself the right operational research (OR) questions, perhaps in this case the general OR question is 'Is there any way of definitively deciding whether teaching specific subject matter will achieve a specific goal?'

§ 6: Explanation and Qualitative Research

In Harris's experiment, for example, the complexities of the problems of inductive and deductive logic and of statistical generalisations are largely ignored, but although this in itself has not really invalidated his conclusions, such omissions may have had the unfortunate effect of distracting his attention from other wider issues.

It has unfortunately led Harris to disregard one of the principles of qualitative, historical and operational research[1], namely, that a problem should be viewed operationally and in its environment and as a whole, and not merely in the perspective of local and traditional scientific skills and frameworks, but also in the climate of social opinion. Such a holistic and operational attitude would in no way have imposed restrictions on Harris's investigation - it would not in itself have excluded the use of random sampling and other statistical methods. Such an attitude might rather have enlarged his perspective, and led to a closer scrutiny of the systems interacting within his random samples, and away from a tendency to regard the sample as a statistical device, and a lesson in grammar as an incidental educational episode. There is more to it than that, and with the benefit of historical

[1] Ary, Jacobs and Razavieh (1990) *Introduction to Research in Education*, Ch.13.

hindsight and the subsequent history of the experiment, it may be enlightening to try to see the problems he was investigating as an operational whole.

The lesson to be learned seems, in the light of the above comments, to lie in the answer to the holistic question. For example, Harris's thesis questions whether teaching 'parsing and analysis' effectively achieves what has traditionally been regarded as its goal. Consideration of the historic perspective is alone suggestive. For many centuries, it was traditionally believed that a degree of competence in communicating in Latin was essential to higher education. While most university text-books were written in Latin, for this and for other reasons, the case for learning Latin, and even Greek, was for many centuries a strong one. In time - and it took time - the traditional benefits of Latin became less obvious, and eventually even the most conservative universities[1] agreed that for the generality of students Latin was no longer educationally essential, *tempora mutantur et mutamur nos in illis*. This came about 1950-1960. But it takes more than a logical argument and a scientific demonstration to achieve victory against tradition, vested interests and the closed mind, to convince some people that the teaching of a subject may no longer serve its traditionally supposed purpose. The great Dr Arnold of Rugby considered Latin was at least a useful discipline for boys. The holistic answer may remove these difficulties, by making the necessary analysis, which might appropriately be described as qualitative analysis.

In this connection, it is significant to note, with regard to the later history of the H experiment, that in some English-speaking areas there has now (1996) been a certain reaction to the problem itself in the opposite direction, sometimes attributed to the rapidly growing demand for learning English as a second language, and the view has been expressed that familiarity with traditional grammatical terminology seems in some ways advantageous to this end. In fact a study of the history of

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[1] The University of Cambridge in 1961 abandoned a minimum standard of 'O' level Latin for Matriculation for all students; many private schools then made Latin voluntary and as a result the teaching of Latin declined, in spite of some attempts to modernise teaching methods.

grammar suggests that in this respect the teaching of grammar has reverted to the original purpose of the Alexandrian grammarians, as mentioned above. In short, it seems that the teaching of traditional functional English grammar using Latinate grammars, may have brought other unexpected benefits, at least partly to be explained by reference to historical factors.

This operational oversight might have been avoided by the use of scientific procedures known as qualitative research.[1] For example, research in Harris's experiment might have involved consideration of certain other systems and other alternatives involved - reasons why a knowledge of the grammatical terminology of a language might be useful in learning a second language, or a study of the interaction of systems involving students, teachers and even parents to the teaching of formal grammar, in the light of the events subsequently described, including also initial research in the early history and origins of 'grammar schools' and the teaching of grammar. At another level, it might have involved interviews and questionnaires with parents, teachers, pupils; and perhaps prospective employers, future possible teachers in universities, and with business colleges and commercial executives who sometimes perceived grammar teaching as an indicator. Inclusion of such aspects all tend, like CCA, to add weight, clarity and conviction to an explanation.

As Harris's account of the experiment makes clear, the various parallel classes described in the five schools involved in the experiment, do not differentiate between the teacher and the class as basically two different interacting systems. It is difficult to resist the impression that Harris might have come to very different conclusions, if he had assumed that a class in a school comprised potentially at least *two* distinct complexes of systems interacting in a special way. For example, if a teacher is 'subtracted' from the class, the class becomes a very different system of multiple interacting entities. The teacher, at the same time may, and sometimes

[1] Ary, Jacobs and Razavieh (1990) *Introduction to Research in Education*, Ch.13.

does, interact with other teachers to form another set of systems. In addition, the parents of the children in the class may also interact, and, as Harris himself concedes, and form sets perhaps supportive of the idea that their children's education was being disrupted educational experiments. This may be hypothetical, of course, but educational research may well take advantage of such qualitative analysis to draw attention to such factors.

It is however relevant at this point to discuss in further detail some of the implications of the systematics approach in academic studies generally. It is the intention then to suggest that the qualitative-analysis and systems-analysis approach can be helpful in sharpening the awareness of university students generally of the need for CCA.

§ 7: Systematics and its Implications

General systems analysis needs further explanation in the present context of what unifies a series of events, so that it becomes possible to predict results, and thus to solve problems. But before this can happen, the single events as variables must be analysed and then synthesised into a 'system'. Thus the first step is to analyse the concepts and define them, and decide what are their characteristics and properties. The final step is to identify and describe the characteristics of the particular system.

Thus the matter of definition and classification is a particularly important conceptual preliminary to systems procedures. The aim of this conceptual preliminary is to generate fruitful theories in the narrow sense. In the broad sense, it is to counteract the fractionating effect of the over-specialism in science that Whitehead, and later Snow deplored[1]. As has already been suggested, the first characteristic of the analysis of any system is that it involves change - transformation, and, as has already been exemplified, it will also include the prototypical characteristics of the system as a whole. A biologist will be thinking in

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[1] Snow (1961) *The Two Cultures.*

terms of a living organism; the engineer in terms of a machine; the educationalist in terms of the person's brain and its ability to reason.

At the present time the tendency is primarily to explain systems either in terms of concept-language or of mathematics. In the present context, there is much to be said for the mathematical approach, for the reason that it is important to understand the interacting element in academic studies. A rough example was given earlier in the analogy of a steam engine and a transformation - the input of steam being the analogue of the operator, and the revolution of the flywheel being the transform. Such an example is however likely to be disturbed by dysanalogies. If, for example, it is suggested (as was in fact suggested above) that in the context of the education system of the classes in schools are system isomorphic with steam engines, is that suggestion valid? It was suggested above that it was not, in so far as the steam engine is a closed, single-valued (therefore determinate) system, whereas the class with its teacher, (with variable operands) will produce variety in output, and therefore tend to be less predictable.

On the other hand, suppose we consider a more purely mathematical instance from physics - the second law of thermodynamics, or perhaps Newton's gravitation algorithm. Are these isomorphic with mathematical models? The answer is, it depends. For example, the very elementary equations used to calculate expansions in metal structures (closed single-valued systems) then such cases may represent mathematical isomorphic models. But cases may occur, as for example with the satellite Echo mentioned earlier[1], when such a system, on close investigation, as with a Mylar sphere of large volume but disproportionate mass-density, turns out not to be inert in an (apparently) closed system. In other words, it is important to recognise that, as with all analogies it is necessary to be acutely sensitive to dysanalogies.

There is much more that might be said - for example of the methods that systematics makes possible for the control of systems by means of feedback and

[1] Chapter VI, §7.

appropriate decision procedures which are highly significant in various ways, though it is impossible to deal with these at length here.

§ 8: The General Academic Relevance of Systems Analysis

It has not been possible to treat the principles of systems analysis generally in greater detail, but the examples included in the text (Chapter X, §2) may to some extent make good the deficiency. The present writer's experience suggests that university students, especially in disciplines that include studies in informatics, management, operational research, computer studies, economics and so on are likely to profit by awareness at least of the existence of the technique, if introduced through such examples and exercises. In addition, GST has its implications in economics, management studies, informatics and of course the behavioural sciences. While at a more advanced level, it involves the higher mathematics of the theory of sets, and application of the sometimes controversial researches of the N. Bourbaki group[1], it is not suggested that this approach at undergraduate level should be anything more than very elementary. It is to be noted, as Ross Ashby points out, such a study of systematics has the immense advantage of being objective and interdisciplinary. It is however also to be noted that the earlier suggestion of Bertalanffy and others that GST might make possible the reduction of all science to a unified whole has long been rejected and condemned[2]. It is indeed difficult to see what form such an epistemology could take.

In previous chapters, the view has been implied, if not specifically expressed, that many modern academic students suffer by being deprived of the discipline and stimulus of such formal studies as modern logic and Euclidean geometry. However, those who have had any experience of modern education are well aware of the almost insuperable difficulties of making such additions to the existing secondary and tertiary curricula. Such difficulties are real and not

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[1] Nicholas Bourbaki was a general in the French army c.1870. His name was taken by a group of advanced mathematicians who continually publish e.g. Bourbaki (1968-) *Groupes et Algèbres de Lie*.

[2] Klir (1972) *Trends in General Systems Theory* p.13.

imaginary. They are not merely administrative and financial, but involve 'opportunity costs,' and the provision of the necessary resources in terms of trained teaching staff. Again, qualitative and operational research may explore other aspects - for example an answer to Harris's query about formal grammar being a waste of time might have profited by conceptual analysis of the concept 'waste'. To what presice alternative use was the time to be put? A language other than English perhaps? Carpentry? The economic concept of opportunity cost is, again, surely here not without its relevance.

The relevance of these useful procedures, operational research and systematics, as described above, to educational problems in particular and academic research and justification of beliefs in general, should be reasonably clear. It should be evident, too, that the process of justifying problem-solving beliefs may involve much more than the provision of statistically satisfying experiments. It involves first a satisfying explanation which must identify the relevant problem, and not merely the statement of what may be wrongly identified as the problem. In the Harris thesis, it might well be argued that the problem under investigation was not the teaching of 'parsing and analysis', but the effective means of teaching the clear and accurate expression of ideas in written English. The teaching of grammar to children might or might not achieve that end. It certainly might not do so, if the children had no clear or accurate ideas to express in the first place, or were distracted by hunger or fear. In such situations, the solution might be the provision of an adequate stimulus, or (if that were not possible) the removal of the distraction. Again, even when the problem is correctly identified, there still remains the question of the formulation of the problem in a way that permits some prospect of solution. It is in fact possible to formulate a problem in such a way as to make it insusceptible of explanation.

§ 9: Explanation and Operational Research

The explanation may fail to satisfy, particularly when the problem systems include complex variables that are not themselves measurable. Analysis of samples of statistical generalisations is not always sufficient, at least in educational research, as the references in the above chapter to the Harris experiment suggest. It was precisely these operational considerations, as pointed out earlier, that originally brought Operational Research into being, and leads it to rely so much on techniques of Explanation, to which we shall turn in due course.

In the present context particularly, explanation might be defined as "the systematic justification of beliefs". In the Harris thesis discussed in the previous chapter, the content of Harris's dissertation was in effect a justification of the beliefs he had formed as a result of his research and his experiments. Subsequent events have rather suggested that at least to some extent certain of Harris's beliefs appear to be mistaken, despite his evident desire to be as objective and scientific as possible in the use of the methods that he chose. In fairness to him, he would no doubt now admit certain mistakes. Likewise, Newton's *Principia Mathematica* is an explanation (in outline) of the physical system which justifies Newton's beliefs about gravitation in the Solar system, as expressed in the famous equation. These beliefs have been modified in certain respects, as a result of subsequent discoveries. It is always of great importance to students to realise, both in presenting explanations of their own, and in trying to understand the explanations of others, that these difficulties should be borne in mind. That is the light in which Harris's thesis is here considered - as an attempt to explain and justify certain academic beliefs.

It is appropriate in this concluding part of the study, to clarify the meaning of such phrases as systems analysis, systematics, and in earlier chapters systems theory and CCA. These words and phrases have reference only to procedures, and not to epistemologies or theories of what constitutes knowledge. They are used rather to refer to ways of thinking that are implied by the historic development of language. It has been suggested that such historic events as the evolution of the neo-cortex and speech and such conspicuous intellectual advances as have resulted from the invention of writing and the significant invention of the printed book, which effectively made modern education possible in the period 1750-1950. It seems useful that academic students and their teachers should be critically aware of the way knowledge has developed in comparatively recent times.

Perhaps the greatest single advance, relative to what is now known, was the perception of Galileo and Isaac Newton that the entities of external world are not sense perceptions of isolated phenomena, but perceptions of systems (like the *quanta* of Planck) consisting of interacting elements which bring about changes in such systems, which might be analysable in language. The immense implications of this, it seems to the writer, are only even now becoming apparent.

To give an example from an earlier chapter (Chapter VI), in the last World War, various scientists had set up (among others Wiener, Ross Ashby and Rosenblueth) had set up research committees, strongly supported at the level of Churchill and Rooseveldt. Their actual achievements are still not available to historians, though after the war many of these distinguished academics enthusiastically taught what came to be called General Systems Theory (GST). The idea seems (from the files of their several academic periodicals[1]) to have been ultimately to have developed some kind of calculus of systems on a mathematical basis - an idea which opened up visions of problem-solving techniques on a vast scale. One of them, Ludwig von Bertalanffy, mentioned above, suggested that such a calculus might eventually make possible a universal GST that might reduce all science to some kind of consistent Truth.

It is of course idle to speculate about what the future may hold, but even our limited knowledge of the variety of systems, of logic, and mathematical reasoning - and, it should be added, the complexity of the systems that comprise the human brain, makes such speculation futile as profitless as programming a computer to

[1] *General Systems Yearbook of the society for the advancement of General Systems Theory*, (1956-); in particular see von Bertalanffy (1962) General System Theory - a critical review, *General Systems Yearbook*, Vol. 7,1.

find an even larger prime. This however does not exclude a specialised academic higher mathematical activity called GST, any more than the search for an ever greater prime excludes Number Theory as an academic activity.

The relevance of all this is to suggest that an awareness on the part of students of what has here been called 'systematics' may be of value to them in their academic studies - such as that implied by Ross Ashby in his text-book. It has not seemed appropriate in the context of this study to make explicit the content of such a course. The intention is rather to demonstrate educational requirement and the source material. This is discussed in more fully in the next Chapter.

§ 10: The Validity of Random Sampling

There can be little doubt that Harris, as well as many others who studied his thesis, regarded the results of his careful experiment as offering a satisfactory explanation of his beliefs. However, although that was the consensus at the time, such a view is open to certain logical and operational objections, as we have seen. The whole area is in fact highly controversial among statisticians, mathematicians and logicians, and may profitably be explored here only to enable academic students to be made aware of the very careful CCA and systems analysis necessary if statistical generalisation based on random sampling is to be used effectively to justify beliefs where highly complex systems in large numbers are involved. Historically, such statistical generalisations were generally used with more confidence (in the absence of a partial understanding of the system involved),than would now be the case.

In the Harris thesis the statistical generalisation process was applied to a very complex problem in the very complex system of institutionalised education, but appropriate variants of the model are effectively used in other contexts, which it may be useful to consider. An interesting and stimulating example is quality control in modern industrial production. Such statistical procedures[1] are applied to ensure conformity with specification in the articles produced. For example, a specification may require to be accurate to +/- 0.0005 cm. To maintain such a specification may require each item to be inspected, with rejection of those that fail to meet the required limits of tolerance. To inspect *all* items in a production run might be very expensive in time and money, so it may be expedient to inspect only a percentage, say a random sample of 5 percent. The situation has its obvious analogies (and dysanalogies) with the educational situation in Harris's experiment, and is well worth considering in terms of GST.

In industrial quality-control procedures, the emphasis is significantly on *control* of the operations and activities concerned, especially on the implications of requisite variety. The contrast is interesting and perhaps stimulating for students to understand. In industry, the procedure is primarily applicable to industrial mass-production - that is, to determinate machines, to systems that are closed and tend to be single-valued, and random sampling is the instrument largely used to secure the necessary feedback to inform that control. It is also used in other fields of management science - as indeed it may apply in educational research, at the other extreme, where systems tend to be open and not single-valued, with more variety and more complexity to control.

Control in industrial production is sometimes maintained, for example, by two charts or graphs, one shewing the means of successive samples and the other their ranges (that is the difference between the greatest and least values in each sample). From these statistics, it is a relatively easy matter to compile control charts, and from these charts to identify and eventually to take steps to bring under control the particular arithmetical means which fall outside the control limits. The steps taken may include studies of the 'capability' of the systems, where process or machine accuracy is tested, and 'process' control is measured and graphs studied with a view to improving performance. In modern industrial enterprises, control is

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[1] Besterfield (1990) *Quality Control.*

exercised by management which requires highly developed technical, administrative and scientific skills, for modern industrial production involves very complex ecosystems, which cannot be discussed here[1].

University teachers and their students will no doubt see the analogies of quality control in industry with the Harris experiment in education. There is the analogy of the school and university examination systems, at least in so far as they represent feedback, both for student and teacher, of the efficiency of the educational systems involved. But there are dysanalogies as well. In so far as the industrial enterprise is concerned, the systems are for the most part (though of course not entirely) closed and single-valued, and the difficulties of exercising effective control of quality, as indicated above, are rather more difficult. Those teachers who have marked scripts in public examinations will no doubt, like the present writer, have had the distressing experience of encountering a batch of scripts reflecting earnest but misguided effort by students, obviously marred by sub-standard teaching. It is gratifying to be able to say that in the writer's experience, when this was pointed out to the supervising examiner, immediate steps were taken to ensure that the relevant immediate control and feedback information resulted in prompt action.

The indiscriminate application of such methods can, however, be harmful. This is especially so when wider operational factors and elements are not given due weight. Whatever may be the evidence of the random sampling, the explanation may fail to convince, or at least its power to do so may be diminished.

In educational systems, the matter of such quality control, for example, is generally made more difficult by the open many-valued systems involved. It is interesting to note that the response indicated by Harris was not to suggest analytical and statistical quality control of the systems involved, with perhaps 'capability' assessment of those involved, but rather to suggest total abandonment of the idea of teaching grammar, and (as Harris suggests) the substitution of a yet-

[1] For a stimulating elementary, though not detailed, account, see Beer (1956) *Cybernetics and Management*.

to-be decided alternative curriculum. But there are obviously many other 'crucial questions', and some of these (such as control) relate to issues fundamental to this study. Limited discussion of these issues will be deferred to the next and to the concluding chapter, while bringing the present chapter to its conclusion with discussion of the first of these conclusions.

The first conclusion here is that random sampling and statistical generalisation hardly represent an appropriate method of explaining solutions to institutional educational problems without careful conceptual analysis and synthesis of the systems involved. The experiment, it would seem, falls short in these respects, mainly because without incorporating such analysis and synthesis, no explanation of the phenomena that Harris investigated would do much more than raise qualified doubts about the merits of teaching grammar, such as might be expressed by the judgment "It could well be a waste of time with many children, and as taught by many teachers, but its abolition should be weighed against its alternatives, the costs against the benefits". For presenting and explaining a given thesis so that it achieves its purpose, as students and teachers should again be reminded, is no easy matter. Assessing the standard of output by random sampling of industrial mechanical process is one thing; using the same method of assessing the output of institutionalised education may well be quite another.

The conclusion on the use of statistical generalisation on the basis of random sampling is certainly that the procedure may yield knowledge, but there are likely in real life precautions to be taken before problems can be solved. For example, suppose a physician is contemplating treating a patient suffering from a condition with a certain drug; he therefore makes enquiries about the statistical probabilities of success, and is told that there in 60 percent of 2,000 cases, there was full recovery, but 10 percent died of heart-failure while undergoing treatment, while a further 5 percent of those who survived the treatment, suffered progressive degeneration and died within 5 years. Such information is normally a generalisation based on a statistical sample, and it certainly constitutes knowledge, scientifically speaking, and is of value to the physician and his patient in coming to a decision about the treatment. Which way the decision will go we cannot predict - that will depend on the individuals concerned. We can safely predict, on the basis of the sample statistics, that probably 60 out of each 2,000 accepting treatment fully recovered, but of course we cannot guarantee their precise numbers - that lies in the future. However, given certain additional information, a professional statistician may be able by use of a probability calculus to make other statistics available. The above represents an example worth thinking about. A version of such statistical generalisation was, as described in the last two chapters, used by Harris, and apparently this knowledge influenced certain educational decisions. Whether Harris's thesis fully justified these decisions is open to doubt, partly on other factors not in themselves statistical, partly on human factors, which might have been improved by CCA and systems analysis.

It is relevant at this point to consider another aspect of statistical generalisation. That is such generalisations as "25 per cent of all adult Australians who smoke more than a packet of cigarettes a day incur a certain risk of incurring lung cancer". If this statement is statistically correct, it may or may not result in reducing heavy smoking. That depends on the individual. But does it justify any particular beliefs about cigarettes being a cause of lung cancer?

That is quite another and highly controversial matter, which must now be discussed. Until about the late 1950s, it was believed that by using appropriate and established 'scientific method' it was possible to give a certain status to categorical universal propositions, by establishing that if 100 percent of cases of heavy smoking resulted in lung cancer, it would be rational to assert the categorical universal that "heavy smoking causes lung cancer". But what exactly is the resultant status of such generalised propositions? Do they really establish causation? Because E always follows C, does not necessarily mean C causes E. Night always follows day, but night hardly causes day. Anyway, how could you show that 100 percent of all cases of anything is the case? From this evolved the idea of a scientific method, which, briefly, redefined what we have called 'beliefs' as 'hypotheses' (the ancient Greek word for 'speculations', the scientific method (it was claimed) was to "test the hypothesis". Then a number of writers[1] using CCA and symbolic logic, were able to show that in fact hypotheses in that sense cannot be tested. All that can be tested is an *inference,* which is physically matched against a material instance. This point, very important to the facts and fallacies of the various means used to justify beliefs, is difficult to explain to students who have not a reasonable grasp of some modern mathematical logic, but an attempt must be made to explain this without using symbolic logic symbolism.

Suppose we take the hypothesis, 'copper conducts electricity.' Translated into ordinary English, this is equivalent to "all instances of copper are instances of conductors of electricity". Now you cannot test "all the instances" of anything, past, present and future (except in trivial cases like books on a shelf) All you can do is to 'test' by deriving an existential proposition, such as 'this particular piece of copper conducts electricity'. The test consists of experimentally matching a piece of copper against a 'electrical-conduction situation', and, be it noted the test is a *physical* act, not an act of *reasoning*, and is applied not to the hypothesis, but presumably to a length of electrically charged copper wire. Assume that the result of the test is positive. We now have two propositions:

(1) All instances of copper wire are instances of conduction of electricity and

(2) This particular piece of copper wire conducts electricity.

What precisely is the logical relation of the two propositions? (2) is consistent with (1), (that is, we can logically assert that if (1) is true, then (2) is true; but it is also perfectly possible for (1) to be false, since (1) refers to all instances, while (2) refers to only one actual instance. (2) certainly does not entail (1). It is thus quite absurd to talk of "testing the hypothesis," unless the population is finite. It is possible only to test specified logically deductive instances. It is

[1] See passage quoted above Chapter IX, § 2.

manifestly absurd to talk of "testing a hypothesis" - a physical impossibility, except to a medieval logician..

It is interesting to note, in parenthesis, that in the symbolism of Russell's calculus there is no way of logically inferring the truth-value of (1) from (2) without introducing new rules of procedure, which is no easy matter with a propositional calculus of the rigour of Russell's. Attempts to do so have been made. In order to give some idea of the magnitude and complexity of the problem, consider a modified version of the Bayes approach, which represents such an attempt.

Let us suppose that there are only 100 'instances' of copper in the universe, and the research plan is to test each serially. It might then be argued, as Bayes suggested, when one instance has been tested of the population of total population to be tested, since the intention being to test progressively the whole population, with 1 percent of the truth, and when 50 instances have been tested, we know half the truth. Bayes (quite rightly) had his doubts about this kind of reasoning, and explained that at least one axiom would have to be introduced before his approach could be put before the Royal Society, of which he was a member. This he was unable to formulate, and died, leaving his MS to his friend, Price, who made his own interpretation and presented it to the Royal Society. This is a much simplified version, but what has been called the problem of Bayes Axiom still remains. Ronald Fisher struggled with it and finally admitted defeat. What has been said in this chapter might seem to suggest grave consequences for research in the social sciences. It is at least clear that such research needs close scrutiny,and the application of CCA andSystematics, quite apart from the epistemological problems to which Laudan has drawn attention.

But the problem justifying beliefs raises profound difficulties. How does the doubting Othello actually feel when he says he "dotes, yet doubts"?. The problems here are great, and should not be trivialised. We must now return to the more general aspects.

This analysis is remote from earlier misleading and conceptually unanalysed ideas of "testing the hypothesis" as a kind of procedural scientific method; it is surprising to find that it is still taught. The realisation of the implications that hypotheses cannot be tested has in the last thirty years, as in the above quotation from Laudan, though here and there are still to be found remote areas where devotees still cherish the flickering flame of 'scientific method' and try to test hypotheses by some ancient ritual . At the time of writing (1998) there is some reason to suppose that the problem of justifying academic beliefs is indeed a formidable one.

INTRODUCTION TO PART IV
SCIENCE AND SYSTEMS ANALYSIS

In the earlier Parts of this study, it was clearly essential to set in the perspective of history the phases through which the conscious use of language and human thought had developed from ancient times. What we call knowledge became possible after finding ways of putting spoken language into written academic language, by the use of conceptual and mathematical language. This in turn brought about the greater understanding of the external world that has ensured the survival of the species, despite of wars, plagues and natural disasters. The fuller development of institutionalised education had to await the complex of events and discoveries that culminated in the invention of the printed book. In the modern world from about 1750 to the present day, this complex of events was eventually to divide the benighted from the enlightened.

This Enlightenment is the most significant period for this study, though its full significance is not always appreciated. Since Newton, however, phenomena were increasingly studied in conceptual terms as components of physical systems of interacting elements that had not at first been understood. Philosophers, mathematicians and others did not realise the implications of the fact that Newton's most spectacular discoveries concerned deceptively simple systems, and as a result it seems that it was not until the nineteenth century and later that academic students became aware that by no means all systems were so simply modelled. The consequence seems to have been that when attempts were made to confine what were seen as Newtonian mechanistic and determinist systems into studies of social systems that involved infinite complexity, that there resulted the kind of judgments that are deplored by Popper in his *Open Society* . On a rather different and more detailed scale, some of the results of such over-simplification of complex systems were noted in the discussion of the Harris thesis.

During the nineteenth century, increasing attention was paid by philosophers of science and by logicians to the problems of appropriately rigorous procedures for formulating academic knowledge of human behaviour and the ordering of human societies. The need then became increasingly apparent, for the application of special procedures in the social, economic and political sciences for the output of these sciences to be totally acceptable. A uniform scientific method is hardly to be expected where the systems involved vary so greatly in complexity, as also do the problems to be solved. The problem of formulating the mathematical principles of natural philosophy is one thing, perhaps very different from formulating the problem of laws or principles of human behaviour, or of the origin and treatment of a malignant tumour, or of defence against atomic warfare. After all, there is no reason to assume that the solution to a particular problem is even possible at a particular point of time, let alone that there exists a unified scientific method applicable to all problems, an epistemology presumably based on an axiomatic deductive set theory, but better than Euclidean - which after all does not describe space!

For these reasons, it has been necessary to stress the importance of critical conceptual analysis and its relation to what might be referred to as 'elementary systematics' in order to avoid confusion with more abstract detailed general systems theory, which is a mathematical and highly abstract discipline in its own right, but which may be of doubtful practical interest or value to undergraduates in their first year.

For such students, the purpose is rather to discuss bridging the gap between secondary and tertiary education, by preparing less mature students for the special academic demands, that, over and above their secondary education, tertiary education will at that point make on them. This is recognised by practically all modern universities in the provision of special tuition to improve the prospects of less experienced students to achieve their potential. Much of the subject matter of the intervening chapters had in mind the possible content of such tuition. The content has to fill a gap that seems to have arisen largely because institutionalised education has been unable to adapt to the greatly accelerated increase in knowledge during and after the two centuries 1750-1950. While the size of the institutionally educated population in more highly developed countries has greatly increased in numbers, in a qualitative sense there has not been a proportionate advance. For example, the implications of the immense advance in mathematical logic and AI, in management studies and operational research, these advances are hardly reflected at all in primary or secondary institutional education. The result is that, in university students, skills in analytical reasoning and explanation are notably deficient. (On the grounds that "one thesis at a time is enough", only the minimum attempt has been made at analysis and justification of the "institutionalised educational deficit" implied in this paragraph and elsewhere in this study. It has seemed more appropriate to concentrate on filling the gap than explaining it.)

It was pointed out above that useful as courses in symbolic logic and the philosophy of science may well be, these subjects are now themselves acknowledged specialist academic disciplines in their own right, and the demands of existing curricula on teaching staff, as well as administrative constraints, tend to make the incorporation of such tuition in non-specialist courses of study virtually impossible.

It is the intention in this concluding Part to suggest that, as a possible alternative to this almost insuperable difficulty, that greater reliance might have to be placed on tuition of the kind suggested by much of the content of this study, at least until modern tertiary institutionalised education is able to adjust itself to the ever-increasing pressures that advances in knowledge and technology are imposing on it.

If students are to make the most of their academic potential the interim gap between secondary and tertiary education needs to be filled with some indication of the more important systematic approaches to the explanation and presentation of knowledge, and to the need for disciplined and careful critical thought, analysis and systematic synthesis.

The main objective of this study, however, has been to direct attention, not so much to the existence of this gap, as to try to specify, or at least to suggest, some more obvious ways in which it might effectively be filled at the tertiary level. These ways emerge from the history of the period itself. Until the eighteenth century, there is in fact a time gap before there occurred the characteristic modern assembly of free and independent minds dedicated to the objective pursuit of scientific knowledge, profoundly rational and opposed to magic and superstition, that was to come as a result of the intellectual achievements of Galileo, Newton and their successors.

Indeed, as a modern historian of science has emphasised[1]:

> In sum, one may say that the sixteenth century sought knowledge of things, and found what they sought, but no more. This knowledge was of many kinds, the results of a restless desire to know, to know especially Nature. So ... in general (this knowledge) was descriptive and practical. It was not analytical; it was not even particularly synthetic. The astronomers, anatomists and natural magicians all saw where their problems lay, but they could not formulate these problems in terms that would admit solution. They could not yet find the method whereby the workings of nature could be understood in rational, simple terms, nor frame a system of the world (for Tycho's was not based upon fundamental principles, but was merely saving the appearances as well as might be). That was left to the next generation, which took such a brilliant step forward that it is properly regarded as the creation of a revolution. Many of the first generation of revolutionary scientists looked to a man of the preceding generation as his teacher and master who had, he thought, encouraged him along new roads to knowledge. Though the scientists of the later sixteenth century had not in fact found the clue to the successful study of nature, they had begun to break with the old ways, and they had indicated a number of possible and impossible paths. Above all, perhaps, they had shown how much it was possible to know, and at the same time, how much there was still to learn. They gave to their pupils an overwhelming faith that the workings of nature could be understood, and, strong in this faith, their pupils found the method and the understanding.

This method and understanding thus emerged slowly, contending against an institutionalised educational system that at first remained largely

[1] Boas Hall (1971) *New Cambridge Modern History* , Ch XV, p.489.

medieval in many of its assumptions, initially taking little account of the magnitude of the discoveries since Galileo, Kepler and Newton. Newton himself formulated his discovery of gravitation in 1665, but did not publish *Principia Mathematica* until pressed by Halley in 1687. It then received wide acclaim, but its implications were no more widely understood or taught than is the work of Russell, Whitehead, Planck and Einstein today. It has been pointed out[1] that though by 1789, there had been forty editions in English, including one for Ladies, *Principia Mathematica* needed popularisation, for the book is very difficult to read. The greatest mathematicians worked for a century to elucidate fully the material of the book.

It was not until Immanuel Kant (1724-1804) began to draw attention to the importance of critical conceptual analysis and synthesis in terms of logic and mathematics, and teaching accordingly, that this kind of real understanding perhaps[2] began to penetrate institutionalised academic education. An important passage from Kant[3] reads:

> A great, perhaps the greatest part of the business of our reason consists in analysis of the concepts we already have of objects. This analysis supplies us with a considerable body of knowledge, which, while nothing but explanation or elucidation of what has already been thought in our concepts, though in a very confused manner, is yet prized as being, at least as regards its form, new insight.

What Kant says here precisely expresses what has been defined, described, and discussed above as CCA. The mode of explanation follows the procedure and most of the assumptions of modern symbolic logic, especially in the matter of normative (or stipulative) definitions of terms[4]. This analytical and critical approach, in which 'mere' things, began to be considered as systems of elements reacting in a complex rather than a simple way. The example of Galileo

[1] Kline (1954) *Mathematics in Western Culture*, p.197.
[2] Kant (1929) *Critique of Pure Reason*, (trans, Kemp Smith 1983 paperback) p.47.
[3] Kant (1929) *Critique of Pure Reason*, p.60.
[4] There are still remain university teachers who do not understand that in specific contexts, any term may be given any stipulated definition.

and the pendulum, and the even more striking example of Newton and the solar system have already been discussed above.

Fortunately, as the passage quoted above, that acute philosopher Immanuel Kant perceived the trend and, in the Critique of Pure Reason, directed attention to it, and the trend continued. For example, the earlier eighteenth-century alchemists and others increasingly thought of the substances they investigated as a having component parts. Boyle (1627-1691), although one of the ablest and more observant early chemists, still thought of substances as simple and unitary (like the metals, water, air (believed to be inert), sulphur, charcoal, the alkalis, though there were other substances thought to be compounds, like the salts made up of an acid part (nitre, vitriol). These early chemists had no concept of gases as separately existing "elastic fluids," and not much understanding of the 'ideas' of heat, flame, burning phenomena. Eventually the vague speculations about combustion of the alchemist Becher (1635-1682) were taken up by Stahl (1660-1734) and there emerged the first modern chemical theory. Stahl used a term to explain his idea, 'phlogiston'. This he described as a negative kind of substance (he had, as yet, no concept of a gas). For example, reduction of a metal calx (oxide) to the original substance required flame to be applied to a substance like charcoal which was rich in phlogiston, which the heat would cause to be given off into the air, re-absorbed by the calx, which would then return to its original state.

The phlogiston theory had a relatively short life, for the reason that it explained only exothermic chemical reactions, and phlogiston (as conceived) could not be physically observed. By 1790 Lavoisier's conceptual analysis of phlogiston, and the consequent discovery of oxygen, displaced that theory, since that concept had much greater explanatory power. Since then, molecular physics has come up with other concepts with even greater explanatory power.

A concept is a word used as a defined term to explain or partly explain phenomena. Thus Stahl's concept emerged from the speculations of Becher, and to it Stahl gave the name phlogiston, but the name may be of no importance, especially as, on analysis, it does not adequately explain what it purported to explain. On the other hand, gravitation was a name used to explain certain phenomena, and in fact proved a conceptual explanation of very considerable power. (However, Newton was well aware that there was much that neither it nor Newtonian physics could explain.) Whatever term Newton had chosen to use in the famous Scholium, it is still no more than a term - the label for a concept used in explanation. It is the explanatory power of the concept that matters, especially when used with other equations; it enables predictions to be made, and control to be exercised, eventually to make possible such achievements as the Apollo mission to the Moon. On the other hand, many terms in the behavioural sciences, such as cognitive psychology, on analysis fail to explain. 'Motivation' for some, fails to explain human behaviour as convincingly as does the self-discipline and self-control that millions of soldiers were trained to exercise in World War II .

Since about 1960, there is fortunately some evidence that changes are coming[1]. For example, there is the growing kind of doubt about the power of statistical generalisation without rigorous logical and systems analysis, except perhaps in educational research. The old mid-thirties positivist idea that the 'latest research', based on random sampling techniques, or on some alleged scientific method, is giving way to much more rigorous analysis[2]. The idea of 'motivation' based on the Harris type of experiment seems less acceptable, and increasingly displaced by the Kantian idea of rigorous conceptual analysis, or, more recently, by computational analysis, using the kind of Gaussian and tensor

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[1]The Wesleyan conference on Induction in 1961; Kyburg & Nagel (Eds.) (1963) *Induction - some current issues*; Cohen & Hesse (1978) *Applications of Inductive Logic - proceedings of a conference at Queen's College, Oxford in 1978.*

[2] Cohen & Hesse (1978) *Applications of Inductive Logic* ; Donovan et al. (Eds.) (1988) *Scrutinising Science.*

network theory suggested by the recent research of Marr[1]. Students might usefully be encouraged, like Newton, to disregard advice merely to read the literature on topics, and instead to subject all concepts (like'motivation') to rigorous mathematical logical scrutiny, in terms of systematics.

It is also significant for systematics that the short life of phlogiston theory was, in part, due to the fact that as a concept it could withstand only a very limited systems analysis. It failed, for example, to explain the phenomenon of electrolysis, when it was discovered in 1800. CCA suggests that Stahl had failed to identify the system of infinitely small particles involved, let alone their interactions. For he had stipulated that phlogiston could not be directly observed, (like ether and later the electron). A sense of historical perspective may suggest that such 'imagined' concepts are still not fully understood even by molecular physicists.

To insist on the retention of the word phlogiston instead of oxygen, is about as ill-advised as to suggest that 'motivation' should be used as a term offering an explanation of the assembly of neuronal modules which 'cause' people to act. Kant refers to these simplified ideas in the passage just prior to that quoted above, as -

> (ideas) which reflect the common fate of human reason to complete its speculative structures as speedily as may be, and only afterwards enquire whether the foundations are reliable. All sorts of excuses will then be appealed to, in order to in order to reassure us of their solidity, or rather indeed to enable us to dispense with so late and dangerous an enquiry.

For example, consider the tendency to neglect the implications of the most recent neuroscientific research[2], and to ignore the need for the kind of

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[1] Marr (1982) *Vision*. This point is expanded in Chapter X.
[2] See, for example, the discussion on tensor network theory of brain function in P.S. Churchland (1986) *Neurophilosophy*, pp.425-455.

computational thinking, with a suitable grasp of the implications of Gaussian systems, such as Marr stresses. Obviously many displaced concepts, like phlogiston and the geocentric solar system, are long since out of date. Institutional education being what it is, students must expect strenuous resistance to new ideas[1].

This tendency has certain profound implications for CCA and systematics, which must now be discussed. These implications derive from the influential work of Kuhn, already referred to above[2], and such criticism as that of Carnap and others mentioned in the passage quoted above[3].

Much remained, and still remains to be learned and taught before the intellectual gap can be closed. It is therefore the intention in these concluding chapters, bearing in mind the conclusions reached in Part III with regard to the Harris thesis, to consider in an analytical way, some of the difficulties of presenting explanations in order to find solutions to academic problems, especially in relation to CCA and systems analysis. The suggested gap is significant in at least three ways.

First, it is again relevant to draw the attention of both teachers and taught in the longer historical perspective of academic studies as sketched above. From the gradual evolution of the anthropoid species in the direction of the astonishing humanoid brain over a million years or more, until (according to some authorities[4]) perhaps a few hundred thousand years ago, when the anthropoid species, living in caves, using tools and eventually fire, decorated

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[1] There is an interesting example concerning Lavoisier and phlogiston, in Donovan et al. (1988) *Scrutinising Science*, pp.105-120, in which is quoted the following remark by Planck "new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it".

[2] See Donovan et al. (1988) *Scrutinising Science.*, p.41.

[3] Ref to article by Loudan, Chapter IX.

[4] Eccles (1989) *Evolution of the Brain*, Chapter 2, pp.12-38.

with drawings of the animals he hunted, while probably communicating this culture with some sort of proto-language. From this perhaps emerged written language and eventually the great advance of the printed book in the sixteenth century. The significance of this event, about 1450, is that it made possible the greatest advance of all in institutionalised education. For hitherto the cultural transmission of learning was available only to the very small minority taught to read and understand the few MS books available in academies and museums. Within a century or so, the great modern universities with the libraries and other stores of knowledge from which they derived the learning which provides the content of all modern academic studies.Then in the shorter, and more significant perspective, the gap referred to in the Boas Hall quotation[1] above began to be filled, and then came the final astonishing period from 1750 onwards.

Secondly, in the present perspective, this gap is particularly significant, for it has a suggestive analogy with the gap between the modern student's secondary and tertiary education, and for similar reasons. The gap between Galileo and the period of the Enlightenment occurred, because, as Boas Hall says in the above quotation, "they could not formulate these problems in terms that would admit solution. They could not yet find the method whereby the workings of nature could be understood in rational, simple terms, nor frame a system of the world".

Thirdly, the consequences of this for institutionalised academic education is profound, as the quotation implies. Once the importance of critical conceptual analysis and systematic synthesis was understood, the way was then open for the truly astonishing discoveries and advances of the last few centuries in the development of the mind of Hss.

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[1] Boas Hall (1971) *New Cambridge Modern History* , Ch XV, p.489.

CHAPTER X: EXPLANATIONS and SYSTEMS

§ 1: The Development of Systems Analysis

In Part III it was concluded that the Harris experiment offered a careful and reasoned explanation, subject to certain limitations and qualifications. In this chapter it is necessary to reconsider what these qualifications are, and, in more general terms, what form the suggested qualitative analysis[1] and synthesis should take in practice. Both analysis and synthesis are involved, for when the student begins to write the concluding paragraph of an answer to an academic exercise, the answer must be satisfactory as to both. Students need to note that qualitative analysis in this sense is one of the more characteristic of those developments of CCA referred to in the Introduction to Part IV. It was also mentioned in that Introduction that another characteristic was the fact that these advances during the period 1750 to 1950 have not been at a uniform rate on all academic fronts, for a variety of reasons. Though it is certainly not possible to explore these reasons in any detail, it is at least relevant, in the context of qualitative analysis, to explain what is meant by the allusion to advances in academic disciplines "not taking place at a uniform rate", for this phenomenon relates not only to qualitative analysis, but also may directly affect the student's understanding of his or her academic studies.

There are many reasons why scientific progress in particular studies may not be uniform; some of these reasons are trivial, others while worth considering, more especially as a general stimulus to critical thinking. Boas Hall in the quotation above[2], mentions that the rate of advance in knowledge after Galileo, Tycho Brahe and Kepler was retarded, and suggests that the thinkers after them (until the eighteenth century) "preferred knowledge of things"[3] rather than of systems; such thinkers still thought in terms that were unanalytical and unsynthetic - meaning that they did not try to

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[1] Qualitative Analysis, not Qualitative research; see Glossary.
[2] Introduction to Part IV.
[3] Introduction to Part IV.

discover and explain in precise terms what they were observing. The result was that they did not formulate problems "in terms (that is, as *concepts*) that would admit of solution".

It would seem, then, that the by the end of the seventeenth century, the basic lesson to be learned from a consideration of the conceptual thinking of Alexandrine schools of mathematicians and philosophers[1] had yet to be, and perhaps still have yet to be, fully learned. This was suggested above in the necessarily brief allusions to the work of these and other thinkers, and in the rather more detailed discussion of the implicit significance of Galileo and Newton to critical and conceptual systems analysis [2].

Since then, in the nineteenth and twentieth centuries, the fact that CCA in terms of systems analysis has only slowly emerged, makes the need for training undergraduates in CCA all the greater. More specifically, the need is for students to be taught to think critically in terms of concepts, and ask, "Do these concepts really explain what they purport to explain?" "Do they really show how the elements in the systems involved interact in order to produce relevant changes in state in the systems involved?"

As suggested above, an understanding of the implications of these earlier attempts to solve academic problems was obscured by the positivist tendency to search for scientific methods or theories, or a single uniform scientific method. Popper would understandably and rightly have claimed that even if such a chimera as a universally applicable scientific method (like the hypothetico-deductive method) were possible, it would obviously be unfalsifiable. On the other hand, a study of the various types of systems investigated and of their characteristics - call it 'elementary systematics' if you like - is quite another matter, for it can hardly be doubted that systems in this sense have extension and can be studied. The needs of such a study might well be met by elementary courses based on the pioneer work of Ross Ashby

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[1] Chapter IV §1-3.
[2] Introduction to Part IV §2.

and Beer. All that can be done in a study of this kind is to explain the need and how, historically speaking, it has arisen. It is appropriate at this point to consider the rudimentary algebra of such a system.

§ 2. The Algebra of systems

The first requirement is some sort of special algebraical representation[1] of the way GST attempts to explore the behaviour of systems, and the ways their elements are transformed, interact and change their states. Such an algebra may take, and has taken, a variety of forms, but it is intended here to attempt to adapt only a very simple algebraic form that can easily be understood by students with a grasp of little more than the elements of secondary school algebra.

The intention of such an algebra is to represent a generalisation of the structure and interaction of the elements in a simplified form of at least some systems that a student in his early academic studies may be asked to explain. It is not suggested that such students should actually use such an algebra for such a purpose, but it is suggested that at least the attempt to do so may stimulate productive academic thinking. In short, such an algebra, properly applied, may facilitate the synthesis of concepts duly analysed in terms of CCA, as discussed in earlier chapters[2].

A dynamic (changing) system, as described above, changes state because of the observed changes in inputs to outputs. These may best be considered initially in terms of a model, called in systems analysis the Black Box. (The 'Black Box[3]' is an imaginary electronic device, coloured black to conceal entirely its inner possible

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[1] The following description is a much simplified version of that devised by Ross Ashby, based in turn on the algebra of Bourbaki (set theory). There is a rather fuller explanation in Beer (1966) *Decision and Control.*
[2] E.g. Chapters VIII, IX above
[3] Ross Ashby (1956) *Introduction to Cybernetics,* Chapter VI - The Black Box..Also refer to article on 'Black Box' in *Cambridge Dictionary of Philosophy* for its use in psychology as well as cybernetics.

mechanisms. There are input and output terminals, and meters to indicate changes of state of the Black Box.)

In this model, variety may be imagined to proliferate as follows. It may be assumed, for example, that nothing at all is known of the way the way in which the input and output lines may be interconnected inside the model Black Box (BB) - that is why it may be thought of as taking on *any* internal connectivity *at all*. An input may increase, decrease, multiply, divide, change in any way, or vanish altogether. The basic idea of this BB model was encourage a fully open-minded approach to any problem on any scale.

In terms of the algebra of sets, each change of state of the BB model system is a transformation. To take a example, sunburn is a transformation from light skin to dark skin. What is acted on (the light skin) is the *operand*, the factor (sunshine) is the *operator*, and what the operand is changed to (dark skin) is the *transform;* while the process (light skin → dark skin is called the *transition)* [1].

An example of a transformation is a simple coding, and might be represented as follows

A → B

B → C

. . .

Y → Z

Z → A

Note that we are not assumed to know anything about the operator (the hidden mechanism of the Black Box) except how it acts on the operands - that is we cannot be presumed to know the actual transformation it effects on the system. In this actual case, CAT becomes DBU.

We now have a vocabulary appropriate to a discussion of systems. The above may more usually represented as:

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[1] What follows owes much to Ross Ashby and to Beer. See Bibliography.

A B ... Y Z

B C ... Z A

Two important attributes of transformations are being *closed* and being *single-valued.* A transformation is *closed* when an operator acts on a set of operands, and creates no new element. A single-cylinder steam engine might be an example. In other words, the set of transforms contains no element that is not already present in the set of operands. Thus in the transformation given just above, every element in the lower line is given also in the upper; thus the set of operands in this transformation is *closed.* This is important, because it avoids the ambiguities of causation. For example, if the operands are those English letters which have Greek equivalents (i.e. all letters excluding j, q, etc), and the operator is "turn each English letter to its Greek equivalent", the transformation is clearly *not* closed. Classes of students are clearly neither closed nor single-valued. The various teachers represent various different operands; the various students imply variable transforms - the result of transfers (inputs) of information from other academic subjects, perhaps. The system is single valued if it is as follows:

↓A B C D

A B D C

But the transformation

A	B	C	D
↓	↓	↓	↓
B or D	A or C	A or B	C or D

Note that this particular system is NOT single-valued. The distinction may be important. An example is the transformation when the operand is a teacher imparting instruction to students. What happens to the individuals (the transform) may show variety in the case of each student. As a consequence, prediction may be difficult. As can well be imagined, since the result of the interactivities of any system may be described in terms of transformations, there may be very large numbers involved. So it is algebraically convenient to express the transformation in terms of *n*. For example, this may be indicated by expressing the operand as n'' (n with a prime). Thus, whatever n may be, $n \Rightarrow n'$. Thus, the transformation:

$$\begin{matrix} \rightarrow & 1 & 2 & 3 & 4 \\ & 4 & 5 & 6 & 7 \end{matrix}$$

may be written:

Operand plus three, or Op. $\rightarrow$ Op.+ 3

Identity: An important transformation is identity, in which no change occurs, and each transform is the same as its operand. For example, in old-fashioned cash registers, each sale could be indicated by pressing levers to register the amount of the sale. If an assistant was required to provide a customer with small change, then the identical transformation would be shown by a flag. If merely change was given, then the flag marked "no sale", which registered the transformation.

In the game of cricket, the runs made during an over would define a distinct transformation. How do cricketer's describe such an identical transformation?

In this case the transforms are all different from one another; each operand gives a unique transform (arising from its single-valuedness). It is thus **one-one**, but not closed. As will later appear, a system which is *closed and single-valued* is of particular importance, for it is a determinate system, and thus has characteristics of considerable interest to students, if appropriately applied, as they may be, using methods now to be briefly discussed.

The Matrix system. All these transformations may conveniently be represented in columnar form, as *matrices*. This method provides a clear means of representing the ways in which even quite complicated systems may be analysed, understood and explained. Some proficiency in the applications of the algebra of systems theory is thus of value to all students, for it makes specific the various ways in which the elements of a system may interact.

A system, however simple or however complex, may be represented in matrix form, as follows. Take a simple transformation like this:

$$\begin{array}{l} \downarrow A\ B\ C \\ \ \ \ A\ C\ C \end{array}$$

This may be represented in matrix form as

$$\begin{array}{c|ccc} \downarrow & A & B & C \\ A & + & 0 & 0 \\ B & 0 & 0 & 0 \\ C & 0 & + & + \end{array}$$

The vertical arrow indicates the direction of the transitions. The convention with given transformations is to put '+' at the intersection of a row and column if the operand at the head of the column is transformed to the element at the left-hand side; otherwise insert a zero. The use of matrices in this binary way greatly extends the scope of GST, especially in dynamic situations.

§ 3: The Symbolic Representation of Systems

It frequently happens with the closed single-valued transformation that it is repeated in a system (the pendulum, for example). As has been shown, Galileo studied this phenomenon as a system - or rather as a Black Box.[1] He knew nothing

[1] See above, Chapter VI §3, Chapter VII §3.

of GST, but his methods were consistent with it. He assumed that he knew nothing of the operand or of the transformation, and so in effect simplified the system by regarding it as a unitary episode, and so considered only the single oscillation. The first step was therefore to ascertain what variety was present in the single swing. Prima facie, there was none, but that was to be ascertained.

It is clear from the above that some systems, when represented in matrix form as suggested above, will be revealed as more complex than others, and something of the degree and kind of complexity will appear more obviously in the binary pattern of the matrices, thus simplifying the synthesis of analysed concepts. For example, the closed single-valued transformation represents a system analogous to a determinate machine, and hence it is more easily described and controlled.

Variety as a concept is important as a measure of information in understanding and controlling systems. The variety of a set of elements is the number of distinguishable elements in that set. For example, suppose the elements in a set (regardless of order) is

c, b, c, a, c, c, a, b, c, b, b, a

The set thus contains twelve elements, but only three distinguishable elements - a, b, c. The word variety in this sense refers either (i) to the number of distinguishable elements or (ii) to the logarithm to the base 2 of that number, when the unit is then called a 'bit'. Thus to say that a set has 'no' variety, is to speak logarithmically, for the logarithm of 0 is 1. The variety of the sexes is 1 bit; of 52 playing cards is 5.7 bits (noting that $\log_2 N=3.322 \log_{10} N$). The reason for using logarithms is that many systems, especially in the social sciences, are very complex and calculations of measures of variety often involve large numbers and powers.

There are two important things for students to note about the concept of variety in systems. First, that variety is the measure of the complexity of a system.

For example, if a given range of operands, as described above, seems to produce a greater range of transforms, then clearly a more rather than a less complex system is indicated.

Secondly, and perhaps equally important, the variety of a system may be increased or decreased (respectively) by the addition or subtraction of information. In other words, increasing effective information decreases its complexity. For example, a group of mono-lingual tourists stranded in a foreign country may find that the complexity of their situation would be simplified and the variety increased if a few interpreters are added to the party. If, on the other hand, the interpreters are subsequently sent away, the system becomes again more complex. This has in turn led to the "law of requisite variety" of Ross Ashby [1], to the effect that "only variety can destroy variety". As Ross Ashby points out, it is absurd for the senior executives in a large institution to demand that an OR consultant should "keep the solution simple", for complex systems with great variety invariably require complex solutions. All this has contributed a great deal to systems analysis[2] and business management, and in other organisational studies that lie rather outside this context.[3] (It might be noted in parenthesis that Harris might have done well to consider the relevance in the experiment considered above.)

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[1] Ross Ashby (1971) *Introduction to Cybernitics*, p.207.
[2] Beer (1966) *Decision and Control* Chapter 12 - Coping with Complexity.
[3] An advisor reminds me that it should be noted that Schilpp's book on Popper is historically interesting as a record of what the thinking was half a century ago. Popper himself as a very active polemicist continued to develop and modify his views until he died in 1996.
But, as I have pointed out in the text, some sense of historical perspective is often useful. Ludwig von Bertalanffy's views of GST have in the course of fifty years or so have given way to something more substantial - for university students, some training in elementary systems analysis (systematics) - for university teachers perhaps an historical, objective and analytical study of the evolution of the various ways that the human brain has tried, and especially the ways it has failed to transmit such understanding of its external world as from time to time have been achieved. As has been pointed out in the text, it is only by such an approach that students and their teachers can be brought to realise the relevance of the invention of the printed book, of the logic of Whitehead and Russell, of the mathematical and analytical studies of systems, electronic and human, which have contributed, and will contribute to institutionalised education.

§ 4: Ross Ashby, Systematics and CCA

However, systems theory as presented by Ross Ashby, and the significance of variety in systems theory, may be highly relevant in the context of this study, in providing a practical approach to systematics. With a knowledge of the structure and properties of systems, Harris for example, might have been more aware of the great complexity of the educational problem confronting him, and the great difficulty of the variety of the systems involved. He considered only two - teachers and taught, and seems to have aware of them as groups. He disregards the educational institutions and systems, and their implications and history. He therefore failed to appreciate the other factors - e.g. the value of grammar in teaching a second language for academic purposes.

Further, systematics is essential to CCA and to the advance of knowledge. It was for example not possible for physical chemistry to advance much until there was recognition that chemical reactions were the result of the interactions of millions of atomic particles. The same consideration applied to the development of modern molecular biology from Darwinian evolutionary biology. Even more significant are CCA and systematics relevant to the social sciences in helping to identify the relevant systems, and thus, by analysing the concepts that may explain them, impart to such sciences the rigour they sometimes lack.

§ 5: Systems, Concepts and Epistemology

Although the above considerations may suggest that CCA and systematics may sometimes suggest possible advances in knowledge in particular cases, this surely does not justify a claim to constitute a unifying solution to epistemological problems. Certainly in this study what are presented are rather methods and procedures, not a general philosophy, but rather a means to familiarise the student with the systems and concepts the student is required to understand, and thus very often stimulate critical thought in terms of systems. The kind of explanations of dynamic systems that he should be training himself to construct are those which may some day be part of his own professional activities. There is some evidence to suggest that the kind of extravagant claims that Bertalanffy and other early enthusiasts made did the cause of GST some harm and among certain practitioners even some discredit[1].

What may be required at this point in time, it is suggested, is a carefully worked short course of a general and interdisciplinary kind, in accord with the professed objective of this study. The relevance of GST to management-based studies is obvious, but, as this is not a management text-book, it is not relevant to discuss the matter further here, except to stress that the OR methods used to solve management problems frequently involve the introduction of requisite variety.

Auguste Comte, with the assistance of his friend J.S.Mill, was perhaps the first to suggest that such a general systems theory would be necessary for the study of social science, or 'sociology' as he called it, and although his thesis, like that of Duhem, was ultimately marked for failure, his efforts did perhaps contribute to the climate that produced what has been called 'intellectual history', and it did at one time occur to the writer that such a study might provide material to 'fill the tertiary gap'. Unfortunately, such a study would have to be selective and hence tend to appear to be anecdotal, even if suitable text-books and teachers were available.

The position at this point, is that we are talking of at least two kinds of systems study. First, at one extreme, there is what might be called the Bertalanffy Vision of GST, and secondly, there is elementary systematics, and CCA. To avoid confusion, it might be helpful to indicate the origins of the less visionary versions of GST. Consider, for example, the analogy of the electronic computer.

The electronic computer was largely the invention of the brilliant mathematician Alan Turing[2] aided by Alonso Church and others. During WW II it

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[1] Klir (1972) *Trends in General Systems Theory,* Introduction.
[2] Hodges (1983) *Alan Turing: the enigma.*

was used by the British and American forces very successfully indeed to decode enemy secret communications, and for other computational purposes. After the war, it became available for peaceful use, but before the invention of miniaturised circuits, computers were designed with cumbersome thermionic valves instead of transistors and quartz crystals and sold to the governments and large corporations and institutions who alone were able to afford them, who might lease their use to others. These machines were designed for the needs of the very complex systems and functions of such organisations, and were designed and planned accordingly. For this, there developed the need for highly trained mathematicians and electronic engineers, with a specialist understanding of a large variety of systems that might be encountered. To fill this need there arose the specialist study of GST. As can be imagined, the GST specialist at the top level had to understand the systems theory of the institution better, and probably much better, than management itself. As explained above in Chapter VIII §3-4, there were available groups of OR and other specialists (like Wiener, Ross Ashby and Beer) who were able to contribute much.

In time various inventions which made it possible to miniaturise electronic circuits to replace the large, cumbersome and very expensive circuitry of these multi-purpose machines, with very compact circuits, and specialised systems programs were designed to meet the business as well as pleasure needs of the individual buyer of the personal computer, and the systematics and concepts involved.

At the same time, surely no one would suggest that advanced knowledge of a general systems theory, even if available and justifiable, should be applied to filling the gap in academic undergraduate studies. It is however significant that developing and applying systems analysis has meant that personal computers can now be cheaply produced and serve a wide and ever-increasing variety of educational purposes. More than that, the teaching of systems analysis in the simplified form of elementary systematics could be used to teach academic thinking in the way suggested in Chapter IV §5 in this study, and in particular as part of the curriculum now to be discussed in a more general way.

In a general way, the curriculum should stress the importance of self-disciplined study, such as is often acknowledged as a kind of pious hope in inaugural addresses to annual intakes of students. Instead it was suggested, in the opening chapters of Part I, that the curriculum should from the outset include a course specifically designed to give students some idea of the analogy of the physiological structure of the body with the neurophysiological structure of the brain, and the need for incorporating support for the discipline of both in academic studies, although of course details lie outside the scope of a purely academic study, and are in the appendices.

It is perhaps relevant to add that,in the present climate of institutionalised education there is a tendency to trivialise and to rob studies of interest and challenge and to minimise certain aspects of educational discipline. Perhaps the introduction of the algebra of systems might be a timely corrective. Time brings changes, especially in the history of the cultural transmission of knowledge. It was pointed out that the early Greek mathematicians like Apollonius of Perga, Archimedes, Eratosthenes (third century B.C) seem often to have derived satisfaction and entertainment from solving problems raised by floating bodies, squaring the circle, as puzzles to be enjoyed for their intellectual stimulus. This is something very different from an attitude that characterised institutionalised education in the 1950s and 60s whereby some secondary studies, like Euclidean geometry, Latin and Greek, axiomatic deductive logic were often condemned as merely elitist, and designed to promote values associated with the interests of a certain class or sect. In addition, from time to time institutionalised education, like many human institutions, tends to serve the interests of its own members rather than those it exists to serve. In some academic institutions the phenomenon of institutional inertia is not unknown, whereby a desirable change in curriculum is resisted on the ground that staff might become redundant, or an investment rendered obsolete[1]. It is here that decisions should be

[1] Sampson (1980) *Schools of Linguistics*.

considered in the light of GST, more especially cost-benefit analysis. This perhaps especially applies to the teaching of CCA

§ 6: The Teaching of CCA

It is perhaps relevant here to remark that education in CCA and systems analysis has only been outlined, and as has already been explained will need to be supported with carefully planned course material with exercises and examples along the lines suggested in the relevant appendices. As already mentioned, the development of such teaching material has not been included in this study as being more appropriate for a subsequent higher post-doctoral study at a later date. The intention is to present CCA and systems analysis as skills to be practised, mastered and used to encourage the student to think for himself, rather than presented as a rounded epistemological theory, whether evolutionary or genetic. The latter, at least in the Piagetian form (1932) has come in for a good deal of criticism in the light of modern neuroscience and condemned by Eccles and others as too "dogmatic and unimaginative,"[1] while an evolutionary epistemological theory has to contend with the strong objections of the neo-Darwinians against all things Lamarckian[2]. At the same time, there are further rich sources of examples of CCA to be mined in the writings of many philosophers of science such as Popper, Quine, Toulmin. Certainly the Essays of Donald Davidson[3] show enviable skills in CCA.

These resources however need to be mined with discretion. Some of their writing offer excellent examples, but their subtlety may not always be as appreciated by undergraduates as it is by epistemologists, as is suggested by the following foot-note.[4]

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[1] Popper & Eccles (1981) *The Self and its Brain* p.562.

[2] There is an interesting critical article on evolutionary epistemology by Michael Ruse in the *Cambridge Dicionary of Philosophy* (1995) pp.253-54.

[3] Donaldson (1980) *Essays on Actions and Events* .

[4] Bertrand Russell tells the following anecdote of himself - Russell asked a shopkeeper the shortest route to a certain town. The shopkeeper called out to a man in the back premises "Gentleman wants to know the way to Winchester." "Winchester?" an unseen voice replied."Aye." "Way to Winchester?" "Aye," "Shortest way?" "Aye, "Dunno." Russell commented, "He wanted,' said Russell, 'to get the nature of the question clear, but took no interest in answering it. This is

Perhaps Russell was being a little hard on the 'modern philosopher', because it is indeed important to get the nature of the question clear and to analyse the systems and the concepts involved, before attempting to frame answers to many questions. It is important to select all such teaching material with discretion and care, for the points made may be controversial, or be over-subtle and dismissed by students as 'hair-splitting'.

The selection of suitable teaching material, if it is to stimulate original thought, needs a judicious mix of both CCA and systems analysis, since a balance must be preserved, and there must be no suggestion of a tilt in the direction of suggesting that somehow there is an infallible scientific method that will be revealed to those who are sufficiently perceptive. It is partly to preserve this equilibrium that emphasis has been placed on examples from neuroscience, which provides ample evidence to suggest that in fact there is no one procedure in CCA, no one universally applicable general systems theory so comprehensive that if painstakingly applied it would be applicable to that most complex of all systems, the human central nervous system.

It may however help with these more difficult problems confronting the teacher and the taught, to consider an instance from the writings of Karl Popper (1902-1995). Popper died at an advanced age, and for much of his life wrote as a philosopher of science. He claimed that his objective was not to teach what science should be, but to describe what in fact the activities were that enabled those he called scientists to make scientific discoveries. His written output was immense, and he was very highly esteemed as a philosopher and as a teacher. The passage below is taken from his best-known work - *The Logic of Scientific Discovery.*

> The empirical basis of objective science has nothing 'absolute' about it. Science does not rest on rock-bottom. The bold structure of its theories rises, as it were, above a swamp. It is like a building erected on piles. The piles are driven down from above into the swamp, but not down to any natural or "given" base; and when we cease our attempts to drive our piles into a deeper

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exactly what modern philosophy does for the earnest seeker after truth. Is it surprising that young people turn to other studies?'

> layer, it is not because we have reached firm ground. We simply stop when we are satisfied that they are firm enough to carry the structure, at least for the time being. (p 111)

In this passage, Popper describes what he regards as the outcome of the principal activity of the objective scientist. It is suggested that by the application of CCA and systems analysis the student should be better able to decide in particular cases whether or how far this is in fact 'objective science.' In this context, the important point to be recognised by the student is that acceptable academic statements are not necessarily absolutely true statements. Precisely why this is so, is one of the most difficult problems in philosophy, and Popper spent the greater part of his life trying to explain its complexity to people.

What is suggested in this thesis is that courses of study in CCA and systems analysis of the kind that have been discussed in these chapters are likely to assist modern academic students to understand and explain their academic studies. Whether these procedures will in fact achieve that end depends on the respective interactions between the content of those courses, the teachers, and the students themselves.

§ 7: Systems and Neurophysiology

It was pointed out earlier that the possible complexity between systems and the possible outcomes of the interactions of their elements is enormous, and in fact consistent with the fact that at all levels, of human life is confronted with insoluble problems[1]. While little is to be gained by distracting students with aspects of life with which they will soon enough become aware, if they are to make the most of their academic potential there is something to be said for directing the attention of students to the fact that complexity may occur as well the simplicity that is so often preferred.

For this reason, academic students may well be made aware of and be stimulated by the challenge of the infinite complexities of their own brains,

[1] Beer (1966) *Decision and Control* for an illuminating explanation in terms of systems analysis, pp.532-36.

experience something of the need for ever more searching systems analysis, leading to increased understanding of the workings of their own brains, and of conceptual thinking.

Much has been said of the importance of the use of language in the development of the brain of Hss. Something, however, is to be learned about systems analysis from the actual neurophysiological structure of the activities involved, and perhaps even more may be learned by students of the mechanisms of their own brains; a recent model of a mechanism for simple language-processing exists. What is referred to is the Wernicke-Geschwind (W-G) model of certain language systematic interactions within certain parts of the human brain.

§ 8: The Wernicke-Geschwind Language Model

We think of language as a concept that is species-unique to Hss, a system of communication and thinking. But it is much more than that when considered as a neurophysiological complex of systems and interacting elements. Language is not just one system of activities in the brain of an individual. There is the act of speech, and the mechanism of neurones that activates the organs of speech, the cerebral systems that recalls vocabulary and activates the construction of sentences. Again there is the auditory mechanism that not only hears and responds to the speech of others, but also monitors the individual's own speech. Each of these systems of activities is located in different parts of the brain. The model for language may be shown by the W-G model, see Figure 3 overleaf.

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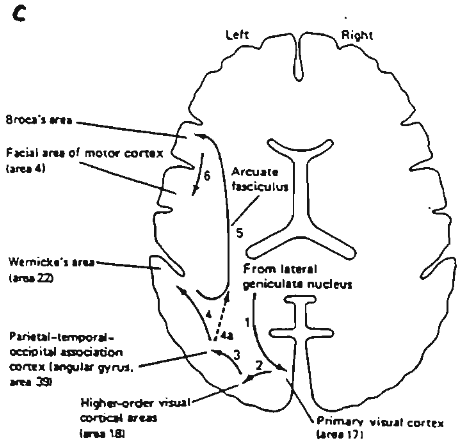
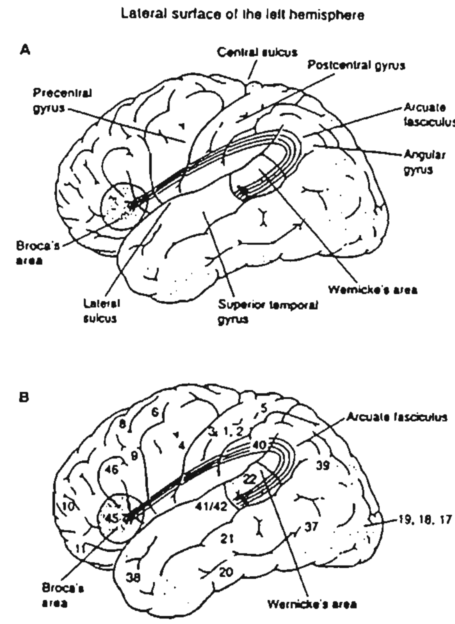


The neural pathways involved in naming a visual object according to the Wernicke–Geschwind model of cortical processing. The diagram here shows a schematic drawing of a horizontal section of the human brain at the level of the corpus callosum. The naming begins with input from the retina through the optic nerve. Recent evidence suggests that the actual flow of information is almost identical to the sequence shown here, except that, following step 3, a component of the arcuate fasciculus (4a) conveys information directly from the association cortex to Broca's area, bypassing Wernicke's area. (Adapted from Patton, Sundsten, Crill, and Swanson, 1976.)



Primary language areas of the brain.

A. The classical nomenclature of gyri and sulci are indicated in this lateral view of the exterior surface of the left hemisphere. Broca's area, the motor-speech area, is adjacent to the region of the motor cortex (precentral gyrus) that controls the movements of facial expression, articulation, and phonation. Wernicke's area lies in the posterior superior temporal lobe near the primary auditory cortex (superior temporal gyrus) and includes the auditory comprehension center. Wernicke's and Broca's areas are joined by a fiber tract called the *arcuate fasciculus*. In the figure Broca's and Wernicke's areas are referred to as *regions* to indicate their status as part of complex networks rather than independent language *centers*.

B. The cytoarchitectonic areas (Brodmann's classification) are illustrated in this lateral view of the left hemisphere. Area 4 is the primary motor cortex; area 41 is the primary auditory cortex; area 22 is Wernicke's region; and area 45 is Broca's region.

Consider the pathway of a simple activity - repeating a word that has been spoken, According to the W-G model, this involves the transfer of information from a membrane in the ear to the area marked 41 and thence for higher processing to area 42, thence it goes to area 39 for association probably with other stimuli (tone, pitch). It then goes to Wernicke' area 22, and thence by the neurones of the *arcuate fasciculus* to Broca's area, where it is translated and identified for grammatical memory and structure. This information is then conveyed to the facial area of the motor cortex that controls articulation that enables the word to be spoken. A similar pathway in Fig. 3C illustrates the naming of a visual object. It is significant that no study had revealed these discoveries until about 1965 when entirely new avenues were opened up, mainly by way of inferences drawn from surgery for tumours of the brain. Such surgery, as remarked earlier, requires the co-operation of the patient under local anæsthesia. The present writer has had the privilege of some discussion with A.H., just such a courageous patient. Such surgery may lead to lesions resulting in forms of aphasia, treatment of which may provide opportunities for further discoveries about the brain.

It is also noteworthy that Hss has developed complex linguistic skills, some of which may be genetically inherited. Experiments with chimpanzees, for example, have shewn that they respond only to a very limited extent to such tuition[1], whereas a human infant at the age of 3-4 years has a vocabulary of about 3,000 words and speaks in grammatical sentences. There is also evidence from lesions that words that are read as written words have modality-specific pathways direct to Broca's area.

For example, the W-G model significantly exemplifies a complex system of interacting elements, typical of many of the systems and mechanisms that students may be called upon to study and explain. It moreover lends itself to critical conceptual analysis. Consider the CCA of the concept of language. The general concept of language may be analysed into spoken language, written language, unspoken language, silent thought, silent reading, (both cursory and subject-specific, sign language, sounds, harmonies, neologisms, intonation, gesture, learning, grammar, semantics; all these perhaps involve different neurophysiological systems - clearly there is ample need for such an analysis before considering critically 'language'. These and other systems may have to be located and considered before attempting to answer the question 'is the capability for language an innate or a learned skill?' Systems were localised by Wernicke, Geschwind and Broca from studies of lesions in patients due to stroke. For example, if a lesion injures the *arcute fasciculus* and disconnects Wernicke's area from Broca's, the patient will be able to hear (Wernicke's area), but not speak without access to Broca's area. If the lesion is in Wernicke's area, the patient can hear, but not comprehend.

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[1] Eccles (1989) *Evolution of the Brain*, pp.76-81.

The significance of all this for systems analysis is pretty clear. To talk of a 'language centre' in the brain is misleading, there are many language systems, as is now known, and the W-G model has been superseded by much more complex models. It seems (as usual with the human brain) that language activity is much more complex than at first appeared. For example most people can recall vocabulary, frame sentences, read aloud, or read silently to themselves - though not all, for some never learn the skill of unvocalised reading, and can be observed to move their lips inaudibly while reading. If students, they are thereby disadvantaged, for silent reading involves a different system and with practice becomes very rapid. Similarly, the spoken language of informal social intercourse is quite different from the language of academic reasoned academic dialectic, even more highly skilled is the language of CCA. At the other extreme is perhaps idle and almost verbally amorphous reverie and 'stream of consciousness' language.

In some ways, the example of the W-G model is analogous to Newton's systematic approach. At first, the neuroscientists grossly oversimplified the concept of language - there was just one language centre - Broca's area. But this supposition soon appeared to lack explanatory power, Wernicke posited the area that eventually bore his name. We now know (as is so often the case) that a whole complex of systems was involved, and in addition at least one other cerebral 'language' system used by neurones to signal to other systems in the brain.

In suggesting a short course in CCA and systematics, it is as an alternative to a course in evolutionary epistemology. There is certainly no suggestion that such a course in CCA and systematics could relate to the problems discussed at the epitemology at Conference at Oxford in 1978, to which the work of Cohen and Hesse refers.

The above information is included here for two reasons. First, such information constitutes an example of the standard of reasoning from evidence, required to justify beliefs in the context of behavioural sciences, and as such deserves careful consideration. Evidence is offered, not mere speculation, on possible reasons for mechanisms on the one hand, or conclusive empirical research on the other. A model was constructed, the Wernicke Geschwind, because the actual circuitry is on a sub-atomic scale that does not permit observation in precise detail. The systems then described are modelled on physiologically analogous systems in less complex organisms, such as Aplysia. Such methods represent a great advance on the vague use of analogue-derived conceptsderived from other disciplines. By way of contrast in the context of research on vision, Marr has used models based on electronic computers, on the basis of which he has in fact developed a procedure he calls 'computational theory'[1]. He and others suggest that purely speculative models concepts like 'motivation' should not be introduced unless supported at least by a model of possible neuronal circuitry, using Gaussian or tensor analysis[2].

Secondly, students need to be aware that modern advances in knowledge and scientific discoveries may be the result of systems research in all sorts of unexpected areas. In this connection, and in relation to what follows, there are certain other approaches to which the attention of students should be directed. A number of philosophers and historians of science have developed the thesis that at least in certain academic studies there appear to be certain fashions or 'vogues' in thinking which come and go. Others reject the idea as somewhat flippant[3]. Certain historians have even suggested that there should be specialist professional studies of 'intellectual history'[4]. One of the most searching discussions in this respect and one that is consistent with the aims of this study attempts to examine the issue raised by means of a kind of historical research[5].

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[1] Marr (1982) *Vision* pp.27-29; 103-4.

[2] For examples, see Marr (1980) *Vision*, p.338; Churchland (1989) *Neurophilosophy*, pp.440-447.

[3] See Toulmin, (1972) *Human Understanding*, Part 1, Chapter 1, passim.

[4] Robinson (1934) *Mind in the Making*; Barnes (1960) *Intellectual and Cultural History.*

[5] Donovan et al. (Eds) (1988) *Scrutinising Science.*

A recent result of thinking along these lines is Kuhn's study and theory of scientific revolutions[1]. Kuhn's idea is that the practitioners of any science may at any time make certain basic or guiding assumptions about standard procedure which constitute the standard or 'paradigm' case, as mentioned above. In the sciences, the paradigms are hypotheses, rules of procedure, definitions, and so on. According to Kuhn it is these concepts that change and bring about the scientific revolutions that an intellectual historian might try to explain For example, the paradigm of the Ptolemaic system gave way to the Newtonian or Copernican paradigm, and in chemistry the paradigm of phlogiston gave way to Lavoisier's discovery of oxygen. Note that of course the paradigm oxygen is not the only word used to explain the chemical substances. There are many terms used in explanation in such paradigm cases.

The particular significance of Kuhn's view is the implication that science accordingly develops *not necessarily* as truth replaces error, or that it is advanced as conjectures are refuted, for, like the cow in the field, Hss learns by experience. These Kuhnian views however are certainly not accepted without qualification by all philosophers of science. There are the sceptics and cynics who suggest that scientific revolutions are an indeterminate matter of mixed motives and emotions and impressions, including self-interest. There are those who turn their epistemological professional skills to the CCA of the concepts 'paradigm' or 'scientific' or 'revolution'. And there are, of course the academics who prefer to think that scientific beliefs approach ever nearer to reality and the truth by the intellectual activities of the scientist.

As this study draws to an end, it as well to specify what it is that really makes the results of academic activities acceptable. Once the student has realised that the mere assertion of a belief is insufficient in an answer to a question in an examination paper, or in an assessment, or essay or thesis, and that acceptable reasons,

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1 Kuhn (1970) *Structure of Scientific Revolutions.*

explanation and justification of all beliefs are required, then it is vital that academic students should understand exactly what makes a submission acceptable.

What the criteria of scientific acceptability are, and how they are determined, is a difficult and important question to answer. Implicit attempts to answer the question have been made by writers from the time of Aristotle and earlier, and progressively explicit attempts have emerged ever since, and in the last half century or so these attempts have been intensified by increasingly alert philosophers and historians of science. The issues involved will be considered in the next and final chapter.

CHAPTER XI: THE ADVANCEMENT OF SCIENCE

§ 1: Changes in Knowledge

It was made clear in the opening chapter, as well as in many subsequent references to historical events, that academic beliefs - the content of what is accepted and taught at universities, are not constant, but do change over time. It has also been explained that the acceptability of the kind of reasoning processes, whether deductive, or mathematical or empirical, or even folk-lore[1] may also change over time. For example, the kind of reasoning used by Newton in *Principia Mathematica* was different from that accepted by Francis Bacon. It was also pointed out in the previous chapter, that it is important that students should be given some understanding what these criteria are that determine the content of academic knowledge. What the student needs to understand in this context is not so much the content of epistemology, as what determines the acceptability of academic studies.

The question of what we call knowledge is itself difficult, and it is partly for this reason that in this study variants of the phrase 'academic studies' have been generally preferred, instead of words like 'knowledge', or 'science.' A more important reason is that the word 'science' tends to be associated with the nineteenth-century positivist assumptions, some of which this study has called in question.

In the previous Introduction[2] reference was made to the four rules of Isaac Newton. These rules themselves hardly provide the full criteria of acceptability, though it is clear enough that flagrant violation of them in giving reasons for answers may in modern academic studies lead to rejection. It is also clear that Newton had reasons for formulating those rules. He himself lived in the century that had seen Galileo severely punished for teaching that the earth moved, when the Sacred Writings declared otherwise. Scientific beliefs do indeed change, and as shown above, beliefs that were acceptable at one time may later be rejected. Even after

[1] Chapter I §3.
[2] Introduction to Part III, §3,

Newton and before Kuhn, "a number of cracks began to appear in the positivist picture of an objective, distinct, value-free, and cumulative science"[1]. As also mentioned above, certain aspects of Newtonian physics, of chemistry, of heat, of the Darwinian theory, of biology were changed. Whitehead and Russell had produced an axiomatic set theory which was effectively expressed as a new and far more powerful symbolic logic than the two-thousand-year-old system of Aristotle. Taking advantage of this, philosophers, logicians and others were able to point out that practising scientists like Rutherford and Bohr did not in fact always conform to the scientific methods advocated by Bacon and J.S. Mill and later positivists like Norman Campbell. Among these critical logicians and philosophers of science in the first half of the twentieth century were Duhem, Carnap, Bridgeman, Reichenbach, Popper and Hempel. They often used methods of critical conceptual analysis to 'tidy up' ideas about scientific activities which (particularly with Popper) still retained something of the older empirical structure, though these writers were not always engaged in scientific discoveries[2].

The effect of these activities was to emphasise the fact that although much may be learned from a study of the history of knowledge of such changes in scientific beliefs as have taken place, such a study may not show precisely what makes the changed beliefs acceptable. In the background there still remained very real epistemological and philosophic problems, as indicated above[3], as well as new discoveries and improved technologies, and mid-twentieth century these anomalies attracted increasing attention from historians of intellectual history, one of them being Kuhn, whose book on *Scientific Revolutions* (1962) attempts an analysis of the factors that may bring about acceptable changes.

This was the situation until about fifty years ago, and has been described as follows:

> The role of anomalies was initially given great emphasis by Karl Popper and his school. The well-known corner-stone of his philosophy of science was that all scientific doctrines (whether specific theories or what

[1] Donovan et al. (Eds) (1988) *Scrutinising Science*, Preface.
[2] Donovan et al. (Eds) (1988) *Scrutinising Science*, p.4.
[3] e.g. Chapters IX, X.

> we are here calling guiding assumptions) which encounter refuting instances should be abandoned without further ado. Popper's claim flew in the face of an older doctrine, associated with Pierre Duhem, to the effect that global theories can always be retained in the face of apparent refutations by introducing suitable modifications in the auxiliary assumptions. In the early 1960s Kuhn entered the fray squarely on the side of Duhem (and Quine), insisting that scientists regarded apparent anomalies for guiding assumptions simply as unsolved puzzles, challenges that reflected more on the abilities of the experimentalist than on the core assumptions at stake[1].

This was followed by the publication of various articles in academic journals or papers read at academic conferences. There are at least two implications that should be noted about the above quotation. The first (1) is that Popper's view implies that academic knowledge develops by what Popper calls conjectures and refutations; that is, when what had been conjectured to be the case is called in question by the detection of anomalies, that conjecture must then be regarded as unacceptable, and "abandoned without further ado". Popper explains elsewhere[2] that this procedure of conjecture and refutation accounts for the growth of scientific knowledge. Implication (2) is that refutation involves an autonomous process. These two implications will now be considered.

What Kuhn apparently means is that he is writing as a historian of science, and his views are his interpretation of that history, but (as just stated) that does not necessarily justify either of the two implications. In fact Kuhn foresees this inconsistency, and he explains that in fact science is not in perpetual revolution - that there is such a thing as 'normal science', and that the detection of anomalies merely creates a 'crisis' condition which may lead eventually to a scientific revolution. This however does not entirely dispose of all objections to Kuhn's theory of scientific revolutions. There were particular objections to possible definitions of 'anomaly', and 'a set of guiding assumptions' - what tests were to be used? In the continuing controversy that ensued, many philosophers of science expressed doubts as to the propriety of using historical evidence in matters of, say, nuclear physics. The answer here is clear enough. It is that scientists in a free country (or 'open society' as Popper calls it) are at liberty to make any comment or

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[1] quoted from Donovan et al. (Eds) (1988) *Scrutinizing Science* p.21.

[2] Popper (1963) *Conjectures and Refutations: The Growth of Scientific Knowledge*, Ch 1.

criticism of any judgment they choose. But in matters of academic studies, such judgments are, in practice, refuted and replaced by conjectures nearer the truth or not, as the case may be. What happens is like any other event a matter of historical fact. As Strawson would doubtless say "sometimes the explanation is better, sometimes it is not." The analogy here is perhaps clinical medicine; with respect to the treatment of various diseases, the history of medicine is very much a matter of "conjectures and refutations".

Kuhn's thesis aroused very considerable controversy about what constituted scientific knowledge, and eventually a group of scientists got together and published a monograph, *Scientific Change: Philosophic Models and Historical Research* (Laudan et al.) in *Synthése* (1986). This invited academics to express their theories, in neutral and carefully defined terms, and a selection of such articles was eventually published in 1988[1]. These articles define the three basic terms used, and describe critically historical case-studies on the basis of these definitions. Interesting as these studies are, it is not intended to discuss them in detail here, except to note that as an historical approach to the problem of what constitutes scientific knowledge, as the editors admit[2], does not seem to get us very far. As the case of Harris's thesis suggested earlier, the pursuit of science is a human activity, and always open to human error; thus if science is to advance invariably in the direction of truth, then each refutation must be followed by a conjecture nearer the truth. The price of that consummation is eternal vigilance (as has been argued in this study) with respect to critical conceptual analysis, and perhaps with some understanding of elementary systems structure, the way ahead may sometimes be a little clearer. It is perhaps even possible to join the expectation implied in the last sentence of Donovan's publication that "the picture that is emerging from studies of this sort represents a dramatic improvement over the caricatures associated not only with positivism but also the first generation of post-positivistic theories of science."

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[1] Donovan et al. (1988) (Eds)*Scrutinising Science*
[2] Donovan et al. (1988) (Eds)*Scrutinizing Science*, p.41.

As this study is now drawing to a close, these remarks are consistent with the objective of the study stated at the outset, which was to fill the gap between secondary and tertiary studies. As is suggested in the intervening chapters, it has arisen over many generations, mainly since the invention of writing, but has increased rapidly in in the last two or three centuries, and in this century at a greatly accelerated rate to the point reached just above. In time no doubt, what has here been called institutionalised education will incorporate this accretion of knowledge and thought, and deliver it at a more measured rate, but in the meantime there is need for specially designed tuition, with a content rather more than advice in essay-writing, and taking account not only of the great advances in knowledge, but also the evolutionary thinking that brought it about. It is important however to note that CCA and systematics, as represented in this study, cannot be offered as an epistemological theory, because the wide definitions on which they rest, would be unacceptable to many philosophers.

It has however been suggested that this Dissertation might fittingly include some kind of reference to the possibility of an evolutionary epistemology. However, to suggest that to frame even a tentative theory along lines that might be academically justified and be useful to undergraduates, might strain not only the intellectual resources of the undergraduate audiences, but also the supply of epistemologists responsible for imparting the content of such tuition. In the light of the formidable difficulties suggested by a reasonably careful study of recent literature of the subject,[1] such a course might confuse rather than enlighten students, and thus be inconsistent with the specific interdisciplinary aims of this study. It is, for one thing, difficult to believe that teachers trained to deliver, and undergraduates to receive, the kind of 'gap-filling' courses implied above, would feel much confidence, let alone enthusiasm, for courses claiming to be based on an evolutionary epistemology.

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[1] Such as Cohen & Hesse (1980) *Applications of Inductive Logic* and Donovan et al.(Eds) (1988) *Scrutinising Science*,

In addition, certain implications of the ideas of Kuhn have supported some philosophers[1] in their claim that there is no one identifiable 'scientific method' (defined as "some set of methods and norms that can be used to demarcate legitimate practices from the rest".) To some, scientific method is nothing more than a sociological phenomenon. The controversy still continues at the time of writing (1998).

Instead, it is suggested that the tuition should take into account not only these implications, but also the great developments in human thinking and knowledge, and also the historical and other cicumstances, such as the inventions of printing and the electronic computer. These all provide almost unlimited source material for interdisciplinary exercises and examples. Indeed, in the course of the research for this study, a number of such exercises were devised, but it was concluded that such a format was inappropriate in a document of this kind.

That the inter-disciplinary approach in this study was important was appreciated from the outset, and in earlier versions sections were included dealing with particular sciences. It became apparent however that such inclusions would make the document unwieldy, and they have accordingly been regretfully deleted. Likewise, the need for discipline neutrality has meant that the study is not presented from any traditional academic perspective. While it is true that the subject-matter of the later chapters suggests an approach to the philosophy of science, this derives from the subject-matter, rather than from the treatment. On the matter of the problem of induction, the constraint imposed by the need to 'fill the indicated gap' for those who are virtual school-leavers, has meant that the basic problems of the philosophy of science could not be dealt with in depth - all that has been done is hang out a few warning signs, like "Danger! Handle with care." As Reichenbach[2] and others have pointed out, adequate discussion of such problems really needs familiarity with the Whitehead-Russell propositional calculus.

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[1] Such as Loudan in the article quoted above, and more recently in the journal of *Studies in the History and Philosophy of Science* (March, 1996) especially p.61.

[2] Reichenbach (1951) *Rise of Scientific Philosophy*. Chapter 13.

This raises the question of what might be called 'systematics'. It was decided that if young students really intended to realise their potential, there was a need, not only for the kind of self-discipline suggested in the early chapters, but also for an understanding of the exacting level of thinking that university studies require. For example, in the early 1960s, undergraduates at Oxford who intended to take courses in social studies like psychology, political science and philosophy, were required before the end of their first semester to have achieved a satisfactory standard in Symbolic Logic. This was no mean achievement, but perhaps still left a gap, and in any event there remains today the difficulty of providing teachers. A better alternative arose from research in systems theory as a means of teaching the skills required for conceptual analysis, and the systems-analysis suggested by Ross Ashby seemed eminently appropriate[1], if suitably modified and simplified after further research. It was however considered unwise to attempt to do more in the present study than incorporate sufficient material to suggest its potential. Hence the inclusion above of the Section on an algebra of systems, adapted from Ross Ashby.

The many references to CCA and to systematics need some final qualification. In the absence of the further practical study, mentioned above, in teaching methods and application, it would be premature to attach more weight to the merits of these skills than the present largely historical evidence will support. As the discussion of the Harris experiment suggested, the merits of gap-filling expedients need to be thoroughly explored, and qualitatively analysed, before a verdict is passed.

[1] See above Chapter X, §2.

APPENDIX A

THE PERSON

Where is the person? The 'divided' brain.

Is there in the Brain a certain area that contains the very essence of that individual - the Mind, perhaps the Soul, the Will, as distinct from the physical Brain ? If there is, then surely it must be located in one hemisphere or the other. The first care of the surgeons after such cerebral operations was, of course, to see that the personality of their patients was not adversely affected. At first, it seemed that the personality was unaffected when the two hemispheres were divided. But the scientists were not prepared to let it go at that.

Among the first of the surgeons to undertake such cases was Dr Wilder Penfield of the Montreal Neurological Institute, from whose work, *The Mystery of the Mind*, the following cases are taken.

Case I: The operation is long, tiring and often dangerous, as post-operative impairment of other brain functions must be avoided. For this reason, as the co-operation of the courageous patient was needed, the surgery usually took place with the patient fully conscious under local anaesthetic and without any sedation (the brain itself being without feeling). First, a large area of one hemisphere is exposed by removal of a section of the skull (this part of surgery generally being under local anaesthesia), and the surgeon, equipped with a low voltage pulsating electrode, at intervals very gently touches the exposed surface. He is separated from his patient by a sterile sheet, but they are close together, and the surgeon talks all the time to the patient as a trusted friend, and to these very brave patients, Penfield pays just tribute.

To read Penfield's account[1] as he meticulously probes this greatest of all wonders, the living thinking human brain, is itself profoundly moving. In one case, Penfield was aware that the epileptic focus was perilously close to the speech area, but he also knew that while the electrode was touching that area the patient would be unable to vocalise. So an assistant , as a test , then showed the patient a picture of a butterfly. The patient looked at in silence, and then snapped his fingers as though in exasperation. Penfield removed the electrode. "Ah! Butterfly ! " the patient immediately exclaimed, "that's the word - I couldn't get the word 'butterfly' and so I tried to get the word 'moth'". The patient had of course not realised that the electrode had made him momentarily aphasic, but the ingenious brain was trying to find a way round the inability to use language. Penfield points out that the "way round" was in another area of the brain, as was the mechanism that enabled him to snap his fingers. Penfield goes on to point out that in describing the experience, the patient significantly used the words "I couldn't get 'butterfly', so 'I' tried to get 'moth' ". To this Penfield adds, in effect, that for this "I" we should substitute the word Mind, whose action is not automatic but which was presenting, as it were, the concept of "butterfly" to the speech mechanism for identification. The significance of this is hardly possible to exaggerate. It suggests some kind of inner, over-riding controlling mechanism - or system, in a sense to be explained later.

Case II: In another case, that of an young South African, when the electrode touched a certain area, Penfield explains the situation as the patient

[1]Penfield (1975)*The Mystery of the Mind*, p 51.

Case II: In another case, that of an young South African, when the electrode touched a certain area, Penfield explains the situation as the patient perceived it. In this case, the electrode touched an area which Penfield calls the 'interpretive' area, and which evoked a vivid 'stream of consciousness' in which the patient was aware of laughing with his cousins on a farm in South Africa. Yet, as Penfield points out, the patient was well 'aware' that he was not in South Africa, but in an operating theatre in Montreal. So, looked at from a purely physical point of view, the patient was experiencing *two* 'streams of consciousness', one stimulated by the environment in Montreal, and the other stimulated by the surgeon's electrode on the cortex. Yet a part of the patient's mind was 'well-aware' where lay the reality. The implications of this 'aware Self' made an immense impression on Penfield.

Penfield suggests that this favours two possible hypotheses, either (a) the activity of an *independent* 'mind-action' - or, (b)the whole situation had created a kind of temporary *ad hoc* mind. In either case, Penfield asks, where does the energy come from ? If with (b), the energy comes from the *ad hoc* mind, then surely the two 'streams' would cause mental confusion; while with (a) the energy must come through channels other than the axons of the neurones, in which case it is difficult to account for it in material terms. In short, here was the patient conscious both of being in South Africa, and conscious also of being in the room in Montreal, undergoing surgery and talking to the surgeon. Dr Penfield was deeply impressed by this, for it was difficult to resist the conclusion that, over and above it all, there was a real and conscious and supreme Mind, looking calmly and dispassionately at all that was going on, yet able to distinguish appearance from reality.

It must be noted that Dr Penfield was primarily concerned with the surgical treatment of epilepsy. As a disease, it has been known for thousands of years, and it afflicts certain animals as well as man. Hippocrates, the father of medicine, studied the disease and noted that certain epileptics tended to re-live earlier experiences. Hippocrates recognised that it came from the brain "when not normal". Penfield realised this too, and used the electrode for the double purpose of (a) investigating the possible focus (since the electrical stimulus sometimes produced a response from that region) and (b) to ascertain (in co-operation with the patient) just what functions were involved. The epileptic discharge always takes place in grey matter, never in white; if the grey matter in the sensory area is involved, a *sensation* is the symptom; if in the motor area, *movement* is the symptom. Now, as can well be imagined, these investigations (quite apart from the relief they brought the patient) have resulted in considerable advances in our knowledge of the brain.

Dr Penfield realised that the main higher level of integration was not, as previously had been thought, in the cerebral cortex, (the neocortex) but in the (evolutionary older) brain stem (the diencephalon). Penfield also reached very significant conclusions about the neocortex. We have already mentioned the great development in size of the human brain, especially in (a) the pre-frontal area (behind the forehead) and (b) in the temporal area (behind the temples). This remarkable development of the neocortex is visible to the surgeon as the convolutions of grey matter of the neocortex, crowded and folded round the diencephalon of white matter within, and are accessible to the surgeon's electrode.

Now - and this is fascinating - in 1940 Penfield noted[1] that it was significant that the removal of the anterior part of the neocortex resulted in a defect in the patient's "capacity for planned initiative". And the posterior part of the neocortex is

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[1]Penfield & Evans Article in *Brain; 58*, p 115 +

superimposed on the auditory sensory cortex, and the visual sensory cortex. What is even more interesting is that when a child is born, these 'new' convolutions appear to be *uncommitted* as far as function is concerned - they are, in neonascence, in the nature of 'spare capacity'. In the view of Penfield, some of this capacity will be programmed in early childhood for language and speech, and some, in both (a) and (b), in due course will be devoted to interpretation of present experience in the light of past experience. This is of course of the greatest interest, and confirms what was remarked above about the prime significance of language as the store of knowledge, and only secondarily as a means of social communication.

From all this Dr Penfield, with further experience and improved methods of exploration, concluded that the evidence suggested that there is a mechanism which, as it were, puts all this additional capacity to good use, in the matter of making the most of past experience, and in the use of language (literal, figurative and conceptual).

Case III: Before dealing with some more general considerations, there is one other case of some interest, which is included as emphasising and enlightening the above cases. In 1962, Dr Penfield was urgently summoned as a consultant to Moscow. It seemed that a physicist, Lev Landau, a person of great importance to the Soviet government, had suffered a head injury in a motor accident and, kept alive by devoted nursing, had been in a coma for six weeks. When Dr Penfield first saw him his limbs were paralysed, his eyes were open but unseeing and unfocused. After careful examination, Dr Penfield suggested an exploratory operation.

Next morning he saw the patient again, but found himself preceded by the patient's wife, a strikingly handsome woman, from whom Landau had been separated for some time. Madame Landau sat beside the bed and calmly explained to her husband that Dr Penfield had suggested an operation on his brain. Dr Penfield stood silently watching the couple. Landau lay motionless in a coma as she told him what Penfield had suggested to the Soviet surgeons.

Then came a startling change. The eyes seemed to focus on his estranged wife. He seemed to perceive, to understand, to comprehend. Madam Landau came to the end of her explanation, and was silent. Penfield significantly adds that "his mind may well have intended to send a message to cause his hand to take hers. But his hand lay motionless." Landau then turned his gaze on Dr Penfield, and their eyes met, but the gaze was soon lost. But the striking thing was that for those brief moments Penfield recognised that consciousness had returned to Landau, suggesting that healing was in process, and so no operation took place.

Briefly, the end of the story was that Landau slowly improved, as the internal bleeding caused by the accident was gradually absorbed into the system, but the damage was such that complete recovery was not possible, though Landau and a loyal colleague later shared a Nobel prize, an occasion at which Landau's wife was present.

Dr Penfield thought this case particularly significant as an example of the way, when consciousness is present (as it was momentarily when Madam Landau spoke to her husband) the 'highest brain-mechanism' (as with the South African in Montreal) seems to be able to activate other mechanisms" to take over from impaired mechanisms. In this case, it seems, the lesion caused by the lesion to the diencephalon was at least partly repaired. For students who are beginning to realise how the various parts of the brain, though individual entities, seem nevertheless to interact systematically, it is perhaps even more highly significant.

responses were quite unlike items normally recalled from memory, as Penfield makes quite clear. When they were recorded and played back to patients, the patients themselves admitted that these responses were much more detailed than their usual recollections, and it seems to be Penfield's view that these responses were related in some way to the basic epileptic condition - as Hippocrates had noted over a thousand years earlier.

This of course raises the question of the existence of the Mind as a separate material entity, and Dr Penfield speaks of its relation to the brain, but recognises that in the present state of our knowledge the question must still remain an open one. Nevertheless, as we shall in due course see, there are other very significant ways of finding for ourselves something of an answer.

Further Cases: Perhaps one of the most remarkable studies was that made by Roger Sperry and his associates in the 1960s. Fascinating as are the details and tests so ingeniously devised, we cannot go into these details here[1]. It is rather the conclusions to be drawn that are of interest to us.

Neuroscientists, as well as philosophers and psychologists, are profoundly interested in the problem of the consciousness of self. Where, in the brain, some of them ask, is this thing called Self, and of which we are so conscious ? The surgical treatment of epilepsy by Wilder Penfield described above was rather different from the commissurotomy of the *corpus callosum*, which in effect involved severing some, and in some cases all, of the huge tract of neurones connecting the two cerebral hemispheres, thus dividing an important part of the brain into two. So, the idea was, if there is a 'consciousness' it must be located in one or the other part ? Was this not an opportunity to locate it ?

So Roger Sperry and his associates sought to study the score or so patients who at that time had had the *corpus callosum* severed, or partly severed, to see whether the relatively isolated hemispheres functioned differently. The details of the tests so ingeniously devised yielded fascinating conclusions, and thus deserve some attention, as do the more general conclusions that emerge. The scientists concerned reasoned that they might well find the Self located and isolated in one hemisphere or the other, for these two hemispheres contain the greater part of the mass of the brain. There had been some earlier operations involving the section of the *corpus callosum* , but they had not been closely studied and it seemed at first that there had been little change in the attitude of the patients. But Sperry and others were not wholly satisfied that the tests used had really allowed for and tested possible separate skills in each hemisphere. So certain ingenious tests were devised.

Sperry knew that because of the optical chiasmus (cross-over) the left hemisphere normally received the right visual fields of each eye, while the right hemisphere normally received the left visual fields of each eye. Sperry wanted to test whether, after section of the *corpus callosum*, this was still the case. The actual tests were designed to segregate the half-images presented to each eye, and so the tests were quite complicated (see figures 4a and 4b below) but the outcomes were clear.

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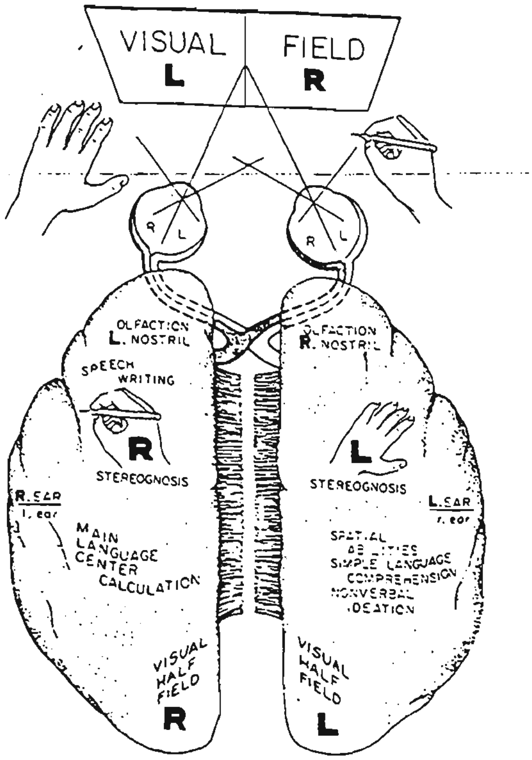
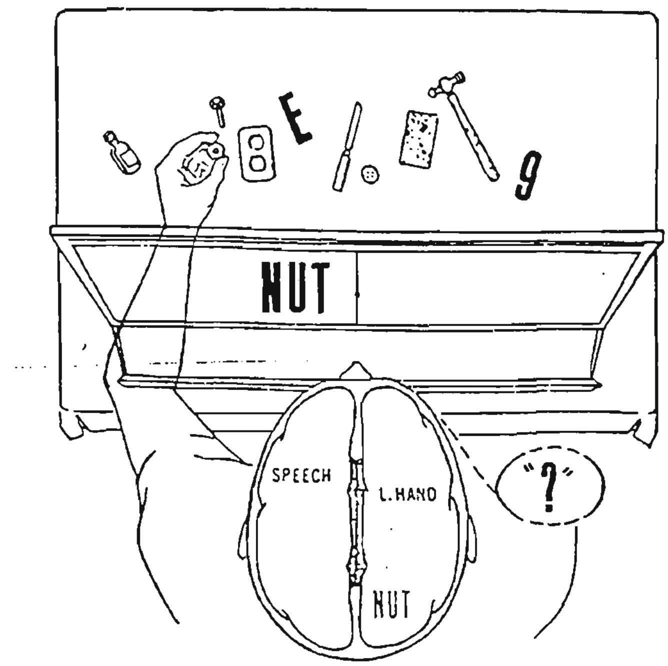
[1]For some details, see Churchland, P.S.(1986) *Neurophilosophy*, pp182-200.



4a Schema showing the way in which the left and right visual fields are projected onto the right and left visual cortices, respectively, due to the partial decussation in the optic chiasma . The schema also shows other sensory inputs from right limbs to the left hemisphere and that from left limbs to the right hemisphere. Similarly, hearing is largely crossed in its input, but olfaction is ipsilateral. The programming of the right hand in writing is shown pictorially to come from the left hemisphere (Sperry, 1974).



4b Names of objects flashed to left half-field can be read and understood but not spoken. Subject can retrieve the named object by touch with the left hand, but cannot afterwards name the item or retrieve it with the right hand (Sperry, 1970)

After section of the *corpus callosum*, what each hemisphere saw, and what it reported was different. The eyes, and what each eye transmitted may have been the same image, but what each hemisphere made of it differed. In fact the LH (left hemisphere) could give verbal answers to questions when asked about what it saw, whereas the RH could not; the RH in short was dumb. For example, when the image was a spoon, the RH when asked by the experimenter what it saw made no reply, while the LH, which was allowed to feel the spoon, replied correctly, "a spoon".

The 'crucial' experiment In other words, in this case it seems that the RH does not understand language. Other tests seemed to confirm this, though not conclusively. With the co-operation of the patients involved, a great deal of research has now been done on what is known as the 'split-brain' problem. The underlying great difficulty, well-known to scientists, is the problem of the 'crucial experiment'. Is there a single and conclusive experiment that will settle the issue once and for all? And what precisely is that experiment ?

APPENDIX B

THE DIFFERENT KINDS OF 'I'

Is it not just possible that what 'I' we are really conscious of being, depends on how well we know ourselves and our own minds - in short how mature we are? After all, the neo-natal baby can hardly be said to be conscious at all, but of course it is in no sense 'mature'. On the other hand, the concert pianist, concentrating on mastering the solo part of a Beethoven piano concerto is very much aware of himself.

Is it not possible then that we use the pronoun 'I' in a rather careless way - to refer to various parts of our total selves ? In order to make this point quite clear just consider some of the ways we use first personal pronouns when we are speaking in the context of the mind and expressing ourselves in such sentences as those which follow.

Group A

I blink my eyes.
When the doctor tapped my kneecap, I jerked my leg.

Group B

I want my mummy
I want my dinner.

Group C

I have a headache.
I have a pain in my legs.
I have indigestion
I am digesting my dinner.

Group D

I am enjoying myself
I greatly enjoy classical music

Group E

I know the two lines are equal in length , but I still think one line looks longer than the other.

Group F

I dreamed that I was alone in the desert
I am afraid of the dark
I am in love with her
I lost control of myself

Group G

I wish I had more money
I am determined to earn more money
I will take this woman to be my lawful wedded wife

Group H

I ought to be faithful to my wife.

Although the pronoun 'I' appears in each of these sentences, its antecedent is clearly not identical in each case. For example, if a man truthfully calls out 'I am drowning', he is referring to his total self - his whole physical person, while if he says 'I have a headache' he is referring only to a sensation in a certain part of his whole self. Consider each one of the above sentences, and see if it is possible to identify the antecedent of each use of the pronoun 'I'.

In Group A "I blink my eyes" the action of blinking does not arise from any brain event or mental event at all - as explained earlier, it is likely to be purely a reflex event taking place in a synapse of a neurone in the spine, and not in the mind or brain at all. Its purpose is sometimes to protect the eye, and at other times to ensure that the surface of the eye is always kept moist. Again, there is an interesting account of an experiment performed by Dr Wilder Penfield during a surgical operation on a conscious patient, with the patient's consent. Penfield gently stimulated a certain area of the exposed brain surface, and the patient moved his arm. When Penfield asked the patient "did you move your arm ?" the patient replied "no, I did not decide to move it; you moved it." This is a nice point of course - but the event that produced the movement certainly did not take place *entirely* in the patient's brain. There is an even more interesting psychological experiment, which has been performed a number of times, and involves post-hypnotic suggestion. The subject while in a hypnotic state is told that when he recovers he will crawl around the floor. Oddly enough, after emerging from hypnosis, the subject will very often make some elaborate excuse to explain his behaviour, such as "I want to have a close look at your floor-covering", and then start crawling around the floor. Whereabouts in the brain did the event then take place that resulted in the crawling ?

In Group B the situation is somewhat different. Suppose the speaker is a 3-year old infant. The same brain event at the age of a few weeks would have perhaps resulted in appropriate body-language and a wailing cry, resulting in the mother picking up her baby and soothing it. The stimulus-event is the child's need for security and reassurance - an awareness perhaps of a psychological emotional need, perhaps genetically transmitted. In short the 'I' that wants mummy is not the whole physical body, or the whole brain or mind, but the event is brought about by the way in which the psychological mechanism of the brain responds to certain external circumstances. With "I want my dinner" on the other hand, the circumstances are purely physical.

With Group C, each sentence in effect reports an awareness of certain internal bodily conditions, and this awareness is the result of stimulation by the brain's proprioceptors - that is the brain's own sensors of internal body states. Of course we are not normally aware of the process of digestion, nor aware of many other internal physical processes. - only when they go wrong. In other words, normally the 'I' in such cases is the relevant proprioceptor(s).

Enough has now been said to make it clear that Consciousness of the Self is a very complex matter. Consider such a commonplace phrase as 'I deceived myself about her'. Who deceived whom ? Is it really possible to deceive oneself ? Or is it just a manner of speaking; a way of saying "various circumstances at the time led me to draw the wrong conclusion about my state of mind." It is of course quite possible to experience an illusion. In that case how is illusion distinguished from reality ?

§ 3: Conscious analysis

Consider the following remarkable example, the so-called 'Sanders Illusion' (Fig 5).

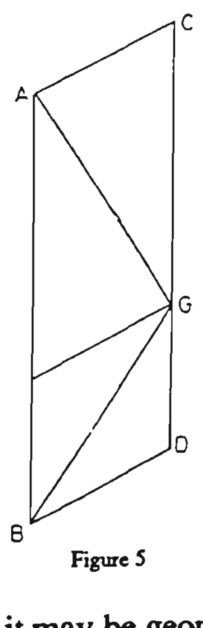


Figure 5

With regard to Fig 5 it may be geometrically demonstrated that AG = GB. If you show the two figures to almost any educated person and give the reasoning, they will agree. (But, very significantly, perhaps a small child would not follow the reasoning).If you give the demonstration to the educated adult then ask the question, "Does AG *look* to you equal to GB ?" the answer is almost invariably

"No". This is a particularly interesting example, and it is important that its implications in this context should be very carefully considered.

When confronted with an optical illusion, we say that "our eyes are actually deceiving us". What does this mean ? It simply means that the eyes, over millions of years , have evolved, not to deceive, but help the human organism to survive. The eye of the eagle, for example, has evolved so that it perceives the movement of a rabbit among bushes hundreds of metres below. Vision, in short, often seems to make organisms aware of what interests and what benefits the organism, and that is not necessarily a complete picture of the whole of reality. Human beings, with the immense advantage of language, have a much greater awareness and capacity to understand and analyse reality, and thus do not need to rely solely on appearances.

The particular interest of the example of the Sanders illusion lies in the fact that we know which of the two answers is correct. There are possible explanations for the illusion, but these do not concern us here. What does concern us is that the *illusion* is the answer of the non-linguistic brain - a subjective answer. The *correct* answer is the product of the human brain's knowledge of mathematical conceptual analysis - in short, the product of education. It is the objective answer given by the consciously trained critical and conceptually analytic brain. The significance of this for academic students and their teachers can hardly be exaggerated, for it is in a sense partly what a university education is about.

This distinction between the unanalytical use of the brain, and the cultivation of conceptualising mental processes is of vital importance, and is often overlooked, even by psychologists. Piaget, for example, and the cognitive psychologists seem to lump all information processing activities together, without distinguishing those that involve and depend on linguistic devices, especially written devices. For example, Piaget describes the development of the brain from infancy without recognising that to develop skills of explanation, analysis to discuss these in an original and imaginative way requires skills that are never acquired by the vast majority of the human race - skills perhaps unfamiliar to the psychologists themselves. The basis of these skills is familiarity with modern symbolic and mathematical logic especially as it has developed since 1910, superseding Aristotelian logic. Indeed, this century has seen the development of a modern calculus of reasoning and problem-solving. It perhaps begins with special instruction in the use of a natural language for academic purposes as a discipline in its own right.

It must not be forgotten that not everyone needs to acquire such skills, and not everyone would have the opportunities to put such a capacity to good use, if they were, by some chance, put in possession of them. On the other hand, a study of modern institutionalised society and the history of institutions and organisations does reveal some extraordinary anomalies. There has been, for example, a very slow realisation of the need for the specific activity of education. For long, in Greek and Roman times, such education as there was, was often entrusted to the slaves of the household, and it was only in Hellenistic times that the need for academic institutional education was recognised, and philosophic thinkers such as Socrates began to suspect that there might be an entity like a Mind or Soul within the human personality

It is important to emphasise that it lies beyond the scope of this study to explore such philosophical or metaphysical implications as the above discussion may have suggested. Whether there is some kind of higher brain or inner Mind or Soul is a very profound question, but not one which is directly relevant in the present context. The 'I' that is directly relevant is the 'I' that makes the decision to revise for an examination instead of watching TV. Clearly, unless this 'I' effectively decides the correct way at least sometimes, the chances of academic success become remote.

It is thus of some importance to the student to understand something of the central mechanisms where decisions of this kind are involved. For example, if a student resolves to represent the university in some highly competitive sport, he or she is aware that this activity will involve a strict regime of training - that is, it involves committal, from time to time, to decide to make a decision to do something he or she might otherwise prefer not to do. That is the category of Self we are here concerned with, and that is the category of mental activity that is vital to successful academic study.

APPENDIX C

CCA EXERCISES

Examples of Conceptual Analysis

Exercises in Conceptual Analysis:

1). Exercises (a)."The space between the Earth and the Moon is not empty, because if it were empty, then the Earth and the Moon would touch". Discuss.

The answer here depends on the concept of space. Space in a cosmic context is not something to which the notion of being full or empty applies. Space may contain (and does contain) bodies having matter, which itself is thought of as consisting of small particles (electrons) with space between the particles. (A vacuum for example merely refers to space from which the atmospheric gases are excluded). Bodies are thought of as touching when there is no matter (whatever that may ultimately be) between them. So the Earth and the Moon can exist in space without touching, just as two billiard balls on the surface of the table may be touching at a particular point if there is no space between them at that point, or alternatively, if there is space between them then they are simply not touching.

This is an example of conceptual thinking, where the analysis of the concepts of space and of touching enables us to explain the difficulty posed. Note how the use of the concrete example of the billiard balls assists the explanation.

(b) "Imprisonment will not convince a criminal that he has done wrong, but will rather make him more hostile to society. Imprisonment as a punishment for crime should therefore be abolished". Do you agree ?

The concept here is ‘punishment’. This is a statement which would be valid if the only attribute of a punishment was to make the criminal contrite. But it may also be to deter others, or to protect society by placing the criminal under restraint.

(c). If you look at your reflection in a mirror, your right hand appears on the left side of the mirror, and your left hand on the right side of the mirror. Why then is your head not at the bottom of the mirror, and your feet at the top ?

This is not easy to explain, but the basic conceptual approach is that such mirror-images must have the basic property of rotation. The right hand appears on the left-hand side of the reflected image of the person in the mirror, because the person whose image it is has half -rotated himself, in order that he may look at his image in the mirror.. If he turns his back on the reflected image by doing another half rotation (making one complete rotation) then of course to a third person the right hand will be on the right -hand side, and the left hand on the left-hand side of the mirror , because of course the person now has his back to the mirror. And if he could half-rotate himself in a vertical plane, of course the head would be at the bottom of the mirror, and the feet at the top. Such is the property of mirror reflection. Of course if you hold a line of printed matter to a mirror so that you can look at it, each individual letter of printing is not half-rotated - the whole line is. This is because when you hold up the page of print to look at its reflection, you half-rotate the page as a whole, not each letter separately.

Again, note how the particularised example in the last two sentences of the above exercise helps to clarify the issue.

(d). "The standard of teaching in Australia is so high that any young Australian of average intelligence, if he studies hard enough and scores sufficient marks, can pass any examination appropriate to his status. Discuss.

This is an example of 'begging the question' which is assuming the issue in question is an actual fact - here, "scores sufficient marks" = "secures minimum pass marks" = "passes". So the last part of the statement amounts to saying "if he passes, he passes".

NB: The correct meaning of the phrase 'begging the question' is very frequently not understood.

(e). "Hitler's failure to learn from the history of Napoleon the folly of invading Russia in the autumn undoubtedly cost him victory in World War II." Discuss.

This statement rather assumes that the events that overtook Napoleon in 1812 would necessarily be followed by similar events overtaking Hitler in 1943-45. It also assumes that Hitler did make an actual study of Napoleon's Russian campaign.

(f) I live at A, and my son lives at B, 10 km apart. On Monday at 8 am I left my house at A and walked the 10km to my son's home at town B by the only direct route, and return back home by the same route at 12 noon. On Tuesday, at 8 am my son left his home at B and by the same route walked to my home at A, and returned, again by the same route, to his home at 12 noon. Can it be proved that on Tuesday my son passed a certain point at a certain time on his walk, where I had been at precisely the same time on Monday ? Give the reasoning clearly.

(g). Give ONE convincing reason for the rule that a man may not marry his widow's niece.

The concept to think about is 'widowhood'. As a widow is the wife of a dead man and no dead man can marry, no situation can arise for the application of such a rule.

(h). "World War II was the greater disaster for the nineteenth century, rather than World War I." What do you think of this statement, in a conceptual sense ?

(Hint: The implied concept is a period of time - analyse it)

Additional exercises in conceptual analysis

(1). If space can be measured, why can't time be measured ?

(2). Making the right decision is simply a matter of weighing advantages against disadvantages, and acting accordingly Discuss.

(3). Miss Jones is the most efficient of the secretaries in our office. She never puts off to to-morrow what she can do today. Under what circumstances might this be true ?

(4). M has an IQ of 130; N's I.Q is only 65. So N is the better choice for this job." Under what circumstances might this be true ?

(5). If it was 50 degrees C in Broome yesterday, and only 25 degrees C in Wollongong yesterday, that suggests it was twice as hot in Broome yesterday as it was in Wollongong. Give a counter-example to show this suggestion is false.

(6). Since a specialist is a person who learns more and more about less and less, then in the extreme case, the greatest specialist of all knows everything about nothing. Is this true ?

(7). If water is composed of 8 parts (by weight) of oxygen to 1 part of hydrogen, does that mean that 900 gm of water consists of 800 gm of oxygen and 100 gm of hydrogen ?

(8). If ignorance is the cause of poverty, how can it be that very many highly intelligent and learned men have been born in poverty ?

(9). "If we knew the cause of cancer, we could cure it". Discuss.

(10). "He says he was born under Leo." Examine the concept 'Leo'.

(11) "For a former monarchist colony to declare itself an independent republic indicates its maturity." Discuss the conceptual reasoning implied by this statement.

(12). A Year 7 child says "My teacher says "Time is money" What did he mean ?" Explain this use of conceptual thinking to the child, without reference to specifically economic terms, but taking account of interest and investment and economic phenomena.

(13) Give as effective instantiation of "All power corrupts" (Lord Acton), and examine the validity of the conceptual thinking involved.

14) Is Empiricism an instance of conceptual thinking ? Consider its relation to the notion of 'top-down' and 'bottom-up' approaches to problem solving.

(15) Give a specific simple example of the use of conceptual thinking to solve (a) a simple economic problem; (b) a 'party political' problem.

(E.g: (a) opportunity cost analysis as in fixed investment in a new machine; (b) loss/gain of electoral votes).

A final question involving conceptual thinking: - Is it true to say that what makes it possible to drink through a straw is suction ?

(Hint: 'suction' is the concept to think about - does a siphon work by 'suction'?

APPENDIX D

ASSUMPTIONS

1) Structural assumptions; an outstanding example is the deductive Euclidean axiomatic system as already described. Its influence was profound and became a characteristic of much of 18th and 19th century thinking[1]. Helmholtz and Kelvin for example seemed to maintain that all phenomena of a physical if not of animate nature can eventually be explained by a unified mechanical theory. Since Einstein applied his newer mathematical methods, that view is no longer unreservedly held, for the original Newtonian axioms do not appear to hold under all circumstances - but that cannot be explained here. Another example is J.S.Mill's 'scientific method', involving sometimes logically invalid assumptions leading to the conclusion that 'scientific laws' were justified by verifying hypotheses.

(2) Assumptions (individual) : a conspicuous example might be the assumption personal to Karl Marx in his system of 'dialectical materialism', though any detailed discussion here is inappropriate. J.S. Mill's assumptions about causation led to a great deal of invalid thinking, because he took little account of 'plurality of causes'.

A thrd extreme case was Sir James Fraser, the anthropologist who wrote a celebrated treatise called *The Golden Bough*, in twelve volumes, based firmly on Comte's controversial sociological ideas. The controversy ceased to arouse much interest long after all interest in Comtian positivism had subsided, but to the end Lady Frazer saw to it that no visitors were admitted who might express views even remotely hostile to those of her octogenarian husband. Academic theories with social implications, it has been remarked tend to "generate more heat than light", But be that as it may, theories are particularly prone to refutation. What makes such theories vulnerable is that they so often represent a reduction from, and attempt to explain more specialised and more varied phenomena. For example, the concept of the so-called Pavlovian conditioned reflex was used by certain psychologists to account for a very considerable range of human behaviour, with the result that the relevant psychological theory became academically somewhat discredited, without being specifically falsified.

(4) It should be noted that general theories, like that of Newton are virtually impregnable, because they can be falsified only under specific conditions, as with Morley-Michelson experiment The specific refutation of popular social theories although an aspect of the structure of sciences, is not one that can be usefully discussed in the present context. Rather more relevant is the effect of the effect of the assumptions involved in particular academic studies.

(3) As mentioned above with reference to Euclid, a marked influence in determing the structure of individual sciences is the introduction and elimination of assumptions, and perhaps one of the most effective techniques to achieve this is CCA, with its emphasis in definition of concepts. Without it, teachers may assume that some aspect was understood that was in fact not understood, and indeed without that particular assumption, the argument might not even be intelligible. Without the CCA of the kind implied by Galileo's activity, the concepts and assumptions of Aristotelian physics would have passed unchallenged. Again, there is the added danger of a concept introducing into a discourse an unjustified assumption. For example, Dalton defined his concept of an atom as an 'indivisible particle'. The Rutherford-Bohr concept however

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[1] See Nagel (1961) *Structure of Science*, p.173

might yet consist of a smaller nucleus, with particles in orbit around it. This additional assumption provided a possible explanation of radiation.

(4) A feature of the historical development of many sciences has often been the introduction of what might be called 'personal' assumptions. On occasion, a distinguished teacher has introduced an idiosyncratic assumption, sometimes justified by formal definition, which has for long influenced the teaching of a science, as for example Piaget. There are many examples in philosophy, economics, psychology and other sciences. In Literary Criticism there is structuralism, post-structuralism, modernism, post-modernism, functionalism, as applied to literary works of art, often without any reference to other works of art (in music or architecture), and without reference to wider disciplines like aesthetics.. Again, Karl Marx defined value as a 'surplus', which he further defined as the share of the total value of output that the capitalist class takes for itself, at the expense of the 'proletariat'. Marx argued that this share continually increased, thus accumulating capital in the hands of the few. This process which he regarded as socially unjust, Marx predicted would eventually lead to revolution, first in Britain, the most highly capitalised country; and last in Russia, the least capitalised country. He and Engels formed the Communist party to support their revolutionary views. Though they were contrary to those advocated by the more conservative Ricardo, the hypotheses on which his definitions and assumptions rested are now often perceived as falsified by history. Very different were the assumptions (mentioned above) of Alfred Marshall (1842-1924), who maintained that man's economic behaviour was based on balancing the satisfaction of his wants (utility) against the avoidance of sacrifice (costs). People thus balance utility gained by purchasing certain goods against utility foregone by not purchasing those they could not 'afford'. Much of Marshall's mathematical presentation of his thinking is to be found in the modern teaching of economics, though to it is now added the work of Keynes on macro-economic theory.

It is as well perhaps that students should be made aware that few factors do more to determine variety in the content, structure and procedures of academic studies than the introduction of assumptions, whether personal or objective. Consider the implications of the Cartesian and Newtonian assumptions, for example. Consider Newton as a young man sitting in the orchard, drinking tea with his friend, and watching the apple fall to Earth, and asking Why ? "Suppose we assume - - - an attraction." That is how it began. Likewise, Galileo "Suppose we assume that oscillations do not in fact get slower and slower until the pendulum becomes vertical and motionless - let us assume that the oscillations are isochronous - what follows ?

It should be added that there is of course nothing wrong with the introduction of such imaginative assumptions, provided they are explicitly stated and consistent with themselves and relevant empirical data, and with other definitions and with other statements in the context. Explanation does not come easily to students, and they may well be encouraged to think of assumptions as a means of stimulating and lubricating thought and understanding.

Analysis of assumptions

Students might be invited to consider for example the assumptions involved in the statement that Christopher Colombus was the discoverer of the New World, or the assumptions that Mount Everest is the highest mountain in the world. What are the assumptions that a judge has to make in deciding the winner of a chess match ? Or a jury in a criminal trial ? Is a computer program a set of assumptions ?

As already stated more than once, the introduction of assumptions must be conscious and deliberate, and their consequences carefully considered. Students of symbolic logic[1] are made well aware of the use of the contrafactual assumption and counter-examples in reductio ad absurdum deductive indirect proofs (ID).

A well-known example[2] of the use of assumption is the Gettier example, which helps to clarify a highly relevant problem epistemological problem that will have to be considered in due course. What is knowledge ? Suppose a given answer is "knowledge is a justified belief in a true proposition". Suppose we assume that a company executive has relied for years on the electric clock in his office, which in forty years has never been wrong. A client walks in and with her back to the clock asks what is the time. The executive glances at the clock, and says "Ten past nine". Unknown to him, the trusty clock had stopped exactly 24 hours earlier. Thus the conditions of 'knowledge' are fulfilled. His statement is true; he is justified in making it; and he honestly believes what he says. What is the conclusion ? It is absurd to assert that he acquire knowledge about the time from a stopped clock. So one possible conclusion is that it is difficult to give a convincing definition of knowledge. That it seems is a good example of the technique of the counter-example.

Another such example comes from Karl Popper[3].

He is considering the view expressed by many positivist and determinist philosophers about the time of J.S.Mill, as discussed above. This is stated as follows. "Any event can be rationally predicted, with any desired degree of precision, if we are given a sufficiently precise description of past events, together with all the laws of nature." This view, which strongly held in the nineteenth century, is equally strongly countered by Popper. One counter-example is to assume that if this determinist view were literally the case, it amounts to asserting that such a scientist would be able to predict, in advance, exactly and precisely. where each note of Mozart's G minor Symphony. All that was necessary was the necessary knowledge of physical laws. Perhaps most scientists these days. might think was pushing determinism a bit far.

Students will perhaps realise from these examples something of the effect of introducing imaginative examples into their thinking. It will be remembered that Galileo used the same kind of reduction to absurdity in his 'mental experiment' with falling stones. He claimed that it was absurd to suggest that two stones bound together would fall faster than each stone falling freely.

It should be noted that what Galileo did, in terms of logic, was to introduce evidence (in this case imagined) which negated his opponent's conclusion (that heavy stones fell faster than lighter ones. In this case, Galileo invites his opponents to consider the manifest absurdity of two stones of equal weight, both falling and not falling at the same rate. They fall at the same rate if dropped separately, and each falls faster when bound together. To imagine that the mere fact of binding the stones together somehow causes the stones so affect each other as to increase the rate of fall, is to imagine an absurdity. A similar case is the defence of an alibi in a court of law. If the jury believes the evidence of the alibi, and concludes the accused was never at the scene of the offence, then it would be absurd to find the accused guilty, unless they accept the absurdity of being in two different places at the same time. Note that such reasoning is just as convincing whether the example is real or imagined. Note also the difficulty of producing

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[1]See Kehane (1973) *Logic and Philosophy*. pp 67-72

[2]See Bradley and Schwartz (1979) Possible Worlds, pp.126-127

[3] See Popper (1982) *The Open Universe*, p.2

evidence of a negation; that the easier way of demonstrating that the accused was never at the scene, is to produce convincing evidence of his whereabouts at the relevant time. Hence also the difficulty of proving that no European had visited before Columbus, and that there is mountain in the world higher than Everest. Here certain acceptable assumptions have to be made.

The use of assumptions in teaching methods

In the logical construction of explanations, assumptions are particularly significant. In fact, the necessity for making assumptions is obvious to anyone who attempts to describe or explain any phenomenon, or system of phenomena, or any aspect of phenomena, as for example the assumptions of Rutherford and Böhr. The assumptions made will depend on a number of factors.

Karl Popper held the view that what we call science is for the most part made up of conjectures that are held to be true, until such time as they are refuted. Thus the 'Big Bang' theory of the origin of the Universe may be regarded as a conjecture, until such time as evidence refutes it, and perhaps an alternative conjecture, like the 'Steady State' theory, may take its place. Conjecture and refutation may in this sense be considered a method of teaching and learning by making assumptions.

In concluding this discussion of the part played by assumptions in thinking, students should be given to understand that the structure of many explanations and nearly all arguments, deductive and inductive, essentially take the form of a hypothetical IF followed by antecedent clause and its consequent - IF certain conditions pertain, then certain conclusions follow. It seems that this is the primordial way of animal thinking, antedating even language. The antecedent, the assumption, arises almost unbidden. It is human language and relevant knowledge that uniquely enables the human being to *justify* the antecedent. These are however not the only analytical skills that need to be developed. There are also to be considered other skills of analysis such as synthesis in terms of systems analysis. and GST. Before that attempt is made, there is something further relevant to be said about the use of hypotheses as assumptions.

In this connection, it might be added, many academic explanations by students (and others) are often confused because of concepts that are ambiguous or undefined. Hence the importance of CCA in explanation. Certain scientists are for example often criticised for introducing ambiguous terms more familiar in other contexts. In this connection students might be invited to consider, as a problem, the difficulties confronting an enquiry involving a very complex and inaccessible system like the human brain. It is not surprising that it was initially assumed that an analysis of the behaviour of human beings in terms of concepts might yield useful information. A possible explanation of the observed superior performance of certain students might be to attribute it to a factor X. What then might be an appropriate CCA of that factor ? Clearly the appropriateness of the name given to X, whether 'intelligence', 'tuition', 'motivation', or what the ancient Greeks called nous is hardly relevant. Students would do well to consider what might be the appropriate procedure for discovering what are the attributes or properties of the factor, leading to a discovery of the characteristics of the system or systems involved.

APPENDIX E

PROBLEM SOLVING

Exercises in Problem-solving

All living creatures almost throughout their lives are faced with problems, and even the simplest unicellular forms in fact seem to be systems capable of solving problems. That is, they are systems in the sense that they are mechanisms that *react* in some way to their surroundings so that they either continue, or fail to continue in their surroundings, fail to survive and perhaps eventually become extinct - as we know many thousands of species have. Obviously if in their first moments of life such systems cannot solve the problem of finding the necessary nourishment, life will indeed be short. Thus to survive you must be among the kind of systems that are able to solve problems.

In this and the following Exercises we are going to consider the general idea of problem-solving *in an objective way* ; that is from the point of view of the system we have been discussing. To the system in this sense then what exactly is a problem ?

Problems occur when any living system is unable but wants to achieve some objective and does not know immediately what action or set of actions must be performed to achieve that objective. Or at least, the system is not programmed to perform the most appropriate actions - in fact it is not even programmed to decide which set of actions, which solution, is most appropriate.

It is at this point that the system needs a conscious human brain with the kind of Worlds of resources, as described above under Topic 3. It is a curious feature of such brains that they deliberately devise problems as *puzzles*, which are a kind of objective problem, in which finding the correct solution is trivial and intended by such brains only to be entertaining or amusing. Problems may in fact be set and solved by human beings to achieve all sorts of goals, not only to get out of difficulties or to amuse, but sometimes things more remote - to gratify ambitions, to achieve power, to defeat an enemy, or for revenge, or hatred, or love, or even just to attract attention.

Anyway, a problem may be something quite tangible and direct in the sense that the objective to be achieved is perhaps to get a book from a shelf above one's reach, or a banana outside a cage - for animals have problems too. Or it may be how to achieve some personal objective, to gratify a desire or to feed some appetite; or at very much the other extreme - it may involve perhaps the problem of organising the resources of a whole country and its population so that at least most of them will feel that they have received a just reward for their efforts. Or it may even be the problem of discovering the origin of the universe. Or again it may be the problem that confronts us at the moment - the problem of finding better ways of finding solutions to problems.

Problems are of course of many kinds, but they do fall into two basic groups - open problems and closed problems. Open problems are problems without specific and determinate solutions, but with lots of possible solutions - Robinson Crusoe wrecked on a desert island was faced with the open problem of remaining alive, to which there were in his case a number of possible general solutions to which he adopted in various ways. On the other hand, if he wanted a device that would enable him to solve the closed problem of being able to tell the time of day, the solution might have occurred to him of using a shadow-stick or a sundial. Solutions to closed problems very often (though not always) involve counting and measuring and hence calculation. Many open problems (of government and organisation, for example) are solved by means that are transmitted by history and tradition, while in the world of animals and insects problems of survival are often solved by means of heredity and instinct - by using methods transmitted not culturally, but genetically.

Human beings, except in the early years of life, do not generally rely on instinct, but rather as they mature they rely increasingly on culturally transmitted skills, and above all on language and on thought to solve their problems. This cultural transmission of knowledge and the various skills of thinking in language have it seems, made possible the development of that phenomenon, unique in the whole universe as far as we know - the human brain, unique at least in the respect that the human brain alone is capable of contemplating the origin, nature and purpose of the Universe. There can be little doubt that it is the problem-solving capacity of the brain of the species *Homo sapiens sapiens* (HSS) that has caused human beings to emerge in the last million or so years as the dominant species on this planet Earth. And perhaps there can be little doubt that no subject could be more appropriate as an introduction to the use of language for academic purposes, than the study of the ways human beings use their brains for the purpose of solving problems.

Having already defined a 'problem', the next obvious question is, what makes a problem difficult?

Most people probably think of the time taken to solve a problem as the measure of the difficulty of solving it. For example if the problem (obviously closed) is to find the greatest prime number less than 10^{12} then this is likely to be difficult in the sense of being time-consuming, especially if the method chosen is to begin by simply testing all numbers x, such that $x > 2$ for primacy, and writing down all the primes (any number divisible only by 1 and by itself) up to 1,000,000,000,000 and giving the greatest of them as the solution, which would certainly take a long time.

But there are measures of relative difficulty other than time - there is the ability of the individual solver. For example, a mathematician whose mathematical training has included the knowledge that primes decrease in logarithmic frequency from lower to higher numbers, might take less time by choosing a method which involved testing for primacy beginning with $10^{12} - 1$, and successively testing lesser odd numbers. Solution will take even less time for one whose mathematical education has included the work of Eratosthenes and his sieve and the use of electronic computers. Thus the relative difficulty of solving a problem clearly has something to do with the method of solution that is chosen, - which in practice usually amounts to the relevant ability of the solver. But choice of method and knowledge are by no means the only factors that determine the difficulty of a problem. What is sometimes called the 'presentation' or 're-presentation' of a problem is another factor that determines the relative difficulty of a problem, and for students it is a very important one, as you will shortly see.

The presentation and the re-presentation of problems.

There are at least two aspects to any problem, as it is vital to any student to recognise. First, there is the way the problem is *presented* (initially put into words) by those to whom it seems to be a problem. Second, there is also the way that the problem appears *to other people* who are asked, or (like examination students) and are *obliged* to consider it a problem.

The distinction is an important one, for very many of the problems of real life are presented to us in a form we may not consider ourselves competent to solve, and so we seek advice and help; thus if a problem concerns personal health, we see a doctor; if it concerns our motor-car, we consult a motor mechanic. The result is that there is (a) the problem as we present it in our own words, and (b) the problem as it seems to us when we talk to (say) the doctor, but (a) may be very different from (c) the problem as the doctor sees it, and different again from (d) the problem as perhaps that doctor represents it to a specialist consultant.

The presentation and re-presentation of problems:

Now the matter of presentation is of considerable importance to us, and deserves a bit of explanation and illustration. Here is an example - the celebrated Nine Dots problem.

The 'primary ' or initial presentation of the problem is put like this:

The subject is given the following array of nine dots, with the following instruction :

*   *   *

*   *   *

*   *   *

Draw four straight lines, without raising pencil from paper, so that the lines pass through all nine dots.

Here is another problem whose presentation repays study :-

A woman went to market with some eggs for sale. To her first customer she sold half the total number of eggs, plus half an egg. Then, to her second customer she sold half the remaining number of eggs, plus half an egg. Again, to her third customer she sold half the number left after the sale to the second, plus half an egg. Likewise to her fourth customer she sold half the remainder plus half an egg. She then had none left. How many eggs did she take to the market ? And note that she broke no eggs.

As is often the case, there is more than one way of solving this problem, but, as a hint, you might begin by considering solving the problem 'in reverse', by asking yourself what is the smallest number of eggs she could have sold to her *last* customer.

An example of a famous problem which in effect was not well-defined is the case of the greatest prime number, which led to the formulation of

Goldbach's Conjecture. Goldbach was an eighteenth-century mathematician who was interested in certain of the problems presented by prime factors. Was there, for example, a greatest prime number ? He explained that there was not, since there is no greatest number - you can always (in our system of numbers) add one more to any number, however large. For this reason, he argued there can be no "greatest prime" - you can always add another integer to it. Notice that Goldbach *did not prove* that there was no greatest prime. What he said was that even if you found a very great prime - call it N, then the next greater number N+1 would have to be tested for primacy (unless it was even) and then the next, and the next - and so on. And so it was claimed Goldbach claimed there was no *problem to solve..*

This however is perhaps not quite correct. We have all had the experience of being confronted with a problem in mathematics that we have had to confess that we have been unable to solve, but that is not the same thing as claiming there was no problem to solve. As it is true, of course, that prime numbers decrease in rate of occurrence in logarithmic order, so perhaps they might be considered as eventually dying away and becoming extinct, like the dinosaurs - so, (you might argue) there would be a greatest prime factor (and a last dinosaur!) - even if no mathematician ever discovered it, so perhaps it is really Goldbach's Conjecture No 1.

Goldbach did however go on to express his belief that all prime numbers greater than 5 were the sum of two primes, but he was unable to demonstrate this, and to this day it remains .Goldbach's Conjecture; - no solution has been found[1], and if you think about it, it is always likely to be, since the only way of demonstrating all prime numbers are the sum of two primes is to test every prime number, and then since the class of prime numbers is infinite, Goldbach's Conjecture must again remain a conjecture. This brings us to the matter mentioned in the opening paragraph of this Section - the matter of finding out facts as distinct from solving problems.

(b) Finding out facts (or information) is not always an activity quite distinct from solving a problem, as we saw in the last paragraph. To solve the problem of Goldbach's Conjecture, as most mathematicians realise, you might in fact ultimately have to test each number to see whether it was a prime or not. Is a problem insoluble then, if for any reason the facts necessary for its solution are not available ? For an example of such a problem, take this : is there life as we know it on any other planet in the countless millions of solar systems in the whole Universe ? Is this an insoluble problem ? The answer is, in terms of our definition of a problem, it is not a problem at all; it is at most a question asking for information, for there is no mention of what the specific problem is that needs this information for its solution - in other words, the problem is not well-defined, for no goal is mentioned. Clearly, there either is or there is not life elsewhere in the Universe. However, as the opinion seems to be that the nearest galaxy to ours that might conceivably contain such a solar system is about 500 light years away, the information may be regarded as inaccessible to us for a very long time to come.

On the other hand there are problems which seem insoluble mainly because we do not even know *what* information is necessary for their solution, which in turn makes it difficult if not impossible to formulate the problem in terms that permit solution.

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[1] Solutions have been claimed, but inevitably challenged.

Then there is inaccessible information of a very different kind which makes many problems insoluble. For example, we can never know for certain the thoughts and feelings in the minds of other human beings. The human brain is of all systems the most complex and unpredictable, even in seemingly simple cases. It is this obvious consideration that makes the problems that confront the social scientists so intractable - not only the psychologists, psychiatrists, economists, political scientists and historians, but also the problems confronting decision-makers in matters of the administration, organisation and management of large modern corporations and institutions which confront their decision makers in the modern world. We may know, or think we know, sufficient of the behaviour of molecules to make predictions on the basis of kinetic molecular theory and nuclear physics in solving certain problems, but neuroscientists can as yet tell us almost nothing of the mechanisms of the mind and brain - no more than can the historian reveal the motives of statesman.

From all this it is surely clear that a systematic approach to problem solving is essential to any study of the use of language for academic purposes. To solve a problem successfully depends on factors other than time; it depends too on the way the solver looks at the problem, on the way the problem is presented to him, and perhaps above all on the way he *re-presents* the problem to himself and perhaps to others, as well as on his relevant knowledge and skills. And remember, to show that a problem is insoluble, you have to be able to show *why* it is insoluble.

Such a systematic approach of course implies an orderly procedure, beginning as we have already seen with:

1). careful formulation or re-presentation of the problem, including

2). the criteria or test of what constitutes a solution:

3). an attempt to assess the task environment of the problem.

This third step we must now consider. The task environment consists of all the rational and permitted steps that *might* yield a solution - including the actual path to the solution. The task environment may be represented as a 'tree' diagram which in the case of a winning strategy in a game of noughts and crosses (tic-tac-toe) may be quite small in space, or in the case of a game of chess, it may be vast.

Below a certain level of education an individual solver may find that certain paths to a solution are simply not yet available. For example, two chess problem-solvers may think they are about the same standard, but in fact what is easy to one person may be difficult to another. A three-year old child, for example, cannot solve a chess problem if the child cannot tell legal from illegal moves. However, since in a particular chess problem there may be one or more paths to a solution, if you teach a child the game and thus make it possible for him to find the right paths, the child can then search for and find the features of the remaining paths that do lead to a solution. These remaining paths will then constitute the *problem-space* for a particular solver. (Of course, there may be many paths that do not lead to a solution).

Like chess problems, many problems may be solved in a series of *episodes*. As we saw, one possible approach to a three-move chess problem, for example, is to try to see what white's final mating move was (that is, the third episode, and then from that perhaps reconstruct white's first move. It will generally be found that not all moves (or episodes) are of equal difficulty, and an investigator of the methods used by problem-solvers will consider each episode as a unit and ask why it was initiated and with what result. Of course (as explained) the 'problem space' of each solver will vary with the individual's ability, which in turn may depend not so much on practice and experience as on education in the analytics of problem-solving. It is quite impossible to discuss in detail the theory of problem solving, or to analyse actual problems in anything like the detailed way involved in the studies referred to, but we we have suggestedsome strategies for a number of problems and representative patterns of solution discovery. If they are given the careful thought and attention they deserve, you will derive much from them not only in improved skills in problem-solving, but in confidence in the capacity and potential of your own brain to solve such problems.

We have already considered the theoretical and the matter of the environmental space of a problem, and the major part these play in determining the difficulty of a particular problem. In the practical problem of the Nine Dots, we saw that by taking a *misrepresentation* of the problem, we faced the IPS with an environmental problem space which did not include a solution.

APPENDIX F

THE AXIOMATIC SYSTEM

The Axiomatic System in explanation as Basic Structure

It may be useful to draw students' attention to the axioms of a system, and the hypothetical assumptions of a model of such a system. It was perhaps this feature that so much impressed Newton with Euclidean and later Cartesian geometry. The axioms or postulates of a system must be independent, consistent with each other, and they may not be derivable from that system, whereas any hypothetical assumptions may be introduced, so long as they are not inconsistent with the model or the axioms. For example, there is nothing inconsistent with the model of a geocentric solar system - it is just possible to have a solar system (in all the millions of solar systems that we are told may exist in the infinite space of the Cosmos) in which there is a static planet, and even a sun in orbit round it. But such a model, as a model, is likely to be very vulnerable. This axiomatic system is one of the most ancient and remarkable of all attempts to integrate 'collections of facts', in a systematic and meaningful way. It was the *Elements* of Euclid that, as we have seen, inspired Eratosthenes and, much later, Isaac Newton and many other mathematicians.

The *Elements* was the work of Euclid, of whom little is known, except for his *Elements*, but he apparently founded a school of mathematics at Alexandria about 300 BC. The *Elements*, in 13 books, not all of which have survived, has a fair claim to be in one way or another, one of the most influential of all books for over 2,000 years. It was apparently Euclid's intention to 'demonstrate' - that is, to *explain* by the most careful and convincing reasoning of which he was capable - the justification for many ancient Pythagorean semi-philosophical beliefs about measurements, including the famous theorem about the square on the hypotenuse. Euclid did not invent the method of 'demonstration', but he did understand the need for very careful explanation, making quite clear what he knew, and what he was assuming, and why. This method has been refined by twentieth-century logicians and mathematicians, and sometimes described as an axiomatic method.

What the axiomatic method amounted to has often been misunderstood. It involved exercising meticulous care in making explicit all assumptions, definitions and rules of procedure. Euclid did not use the Greek word axiom at all in the sense used by modern logicians, nor as used by Aristotle, meaning a self-evident rather than a deductive theorem. Euclid begins the first book of the *Elements* with 23 definitions, 5 postulates, and 5 'common notions'. As all students sooner or later realise, one of the great difficulties in any explanation is to know where to begin, and how much, and what, to assume. Aristotle carefully explains[1] that any investigation begins with some truths that cannot be proved, but must be assumed. These he calls first principles - definitions of such mental constructions as lines and circles. These are postulates such the famous fifth postulate, that there are parallel straight lines; and as well axioms, or 'common notions' (ennoia), such as 'things equal to the same thing are equal to one another.' It should be noted that the Greek word ennoia does not mean 'axiom', and that to Euclid a postulate was to be accepted rather than proved, while what we call an 'axiom' is 'self-evident' and cannot be proved. Demonstrations of the fifth postulate do exist, but they are not Euclidean.

[1]Aristotle: *Posterior Analytics* i. 6,74, b 5.

Over the centuries these 'notions' (ennoia) have been much discussed, and attempts have been made to add to and reduce them. It is also claimed that 'the whole may be greater than the sum of the parts" should be included. It has even been claimed that they are not really Euclidean. Aristotle considered that the ennoia have to be accepted, because it would be impossible to reason geometrically without them. The more axioms and/or postulates you have, the greater the number of theorems you can deduce, though there are limits.

Unfortunately, we cannot discuss the matter in greater detail here, though one cannot help regretting that the word "axiom" has been chosen by Russell and others for a term in modern logic which has a meaning rather different from the Euclidean. The conclusion to be emphasised is the need for meticulous care in explanation to make explicit all assumptions - even the most obvious. Many of the theorems that Euclid "demonstrated" by means of his system had been used by the ancient Egyptians for many centuries as rules of thumb for making measurements (mainly of land) before the proofs were discovered and demonstrated by mathematicians like Pythagoras, Apollonius, Euclid, Diophantus and others.

For the modern student, the significance of Euclid lies in this axiomatic method, or, more specifically, the logic of modern axiomatic set theory that has emerged from it, largely as a result of the work of Frege, Peano and Bertrand Russell in the early 20th century. This led directly to the Whitehead-Russell *Principia Mathematica* of 1910, and to the founding of modern symbolic logic, and eventually to the electronic computer. The original Aristotelian and Euclidean system is thus perhaps the most ancient of all attempts to integrate "collections of facts", *in a systematic way*. It was also one of the most respected methods, and was for long thought to be flawless, and in fact thought to describe space. This, it is now known, Euclidean Geometry does not do, and neither is modern axiomatic set theory universally applicable. But its significance, in this context, is such as to deserve a paragraph or so.

Unfortunately, this explanation will have to be mathematical, but it will be kept as elementary as possible, and well within the understanding of a secondary school student. It is however important to follow the explanation as closely as possible, as it is important to an understanding the status of the sciences today.

The idea of an axiom, as mentioned above, goes back to Aristotle who asserted that any reasoned argument must begin with some assumptions, depending on what branch of knowledge was involved. The most ancient and familiar example of an axiomatic system is that of Euclid of Alexandria and his geometry (about 300 BC). Euclid as a geometer was concerned with methods for redrawing boundaries after inundations of the Nile and like problems of measuring and describing space. He was, for example, well aware that with the aid of cord knotted at unit intervals of 3, 4 and 5 along its length, it was possible to construct a right angle. But how was he justify the underlying rules in this and similar cases ? What was to be the initial data on which he could build a convincing argument ? It is noteworthy that Euclid's method was to devise a kind of simplified model of space, with careful definitions of such mental constructions as the basic geometrical figures ("a triangle is a three-sided rectilinear plane figure"), with rules for the formulation of statements and for the procedures for drawing inferences from them. In addition he introduced a number of basic assumptions (called *postulates*) which he considered should be accepted without the need of proof. Postulate 5 was the famous "parallel" postulate which in effect stated that parallel lines did not meet however far they are produced in either direction. Euclid attempted no proof of this postulate, and it has been much criticised ever since, as not really being of this postulate, and it has been much criticised ever since, as not really being "self-evident". However, it is the case that no-one doubts its *truth*.. The point is, in what way does this matter ? We will however return to this shortly.

Euclidean geometry is a very remarkable intellectual achievement indeed, and has remained as a model for such systems for over 2,000 years. It should be noted that cardinal arithmetic may also be formulated as an axiomatic system. As it is important to have a clear idea of what constitutes an axiomatic system, so we shall construct a very simple one, as follows, in outline :

The system is defined as consisting of 2 sets of points, set S and set A, each containing 3 members :

Some members of set A are related to some members of set S, and vice versa,

The axioms are :

1). Any 2 members of set A are related to one particular member of set S:

2). No member of set A is related to more than two members of set S

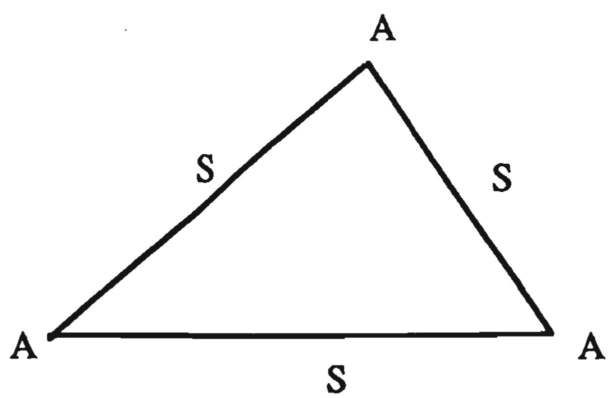
3). No member of set A is related to only one particular member of set S :

4). Any two members of set S are related to one member of set A.

5). No member of set S is related to more than two members of set A.

This may not seem intelligible, but note that this is to be taken as description of an certain system, but merely the a statement of certain definitions, together with certain axioms or observations from which we may infer something about the behaviour of any system that fits these conditions. This is because in constructing an axiomatic system, it is generally necessary to use statements or propositions (like the axioms above) in order to use the system to derive theorems, and so it is also usual to include rules of syntax for such statements, as well as rules and definitions of any symbols used. But for the sake of preserving simplicity, we will take these steps for granted, and go on to the next step in making its meaning clearer, which is to is to devise a functional model to fit it.

The reference, in the axiomatic conditions outlined, to two sets of threes suggests that we might use the sides and angles of a triangle as a model of this very simple axiomatic system. This should fit the system, since the sides and angles of a triangle consist of sets of points. So suppose we make set A = the three Angles, and set L = the three straight lines, the sides S of a triangle, as follows : (See Figure below).



If you carefully check through the definitions and axioms, substituting set A for the angles, and set S for the sides of the triangle in Fig. 8, you will see that these conditions do really map on to the triangle model. Now the point is that from such definitions and such observed axioms, we may be able deduce some theorems. In this particular system, we cannot deduce many theorems, because of the definitions and axioms we have chosen - but we can deduce, for example, the theorem that no A can relate to each member of set S - this would be inconsistent with axiom 2, and the definition that limits the set A to 3 members. (Of course, you might say that a glance at the diagram shows this is not possible, but that is empirical and not axiomatic deductive reasoning).

What this detail amounts to is that the truth or falseness of axioms of a deductive system is a purely external property of any such system. You can invent them - as we have just done - but if you are going to draw logical conclusions from them the axioms must be consistent with themselves and sufficient to enable inferences to be drawn.

You should also now realise the consequences of omitting to provide full definitions and rules of procedure. We have 2 sets each of 3 members, which means that from the data given we cannot say whether the set ASS is to be considered as a different set from SAS. To be able to decide that, we need a definition of the term "relate".

You should particularly consider the consequences to our simple system of adding sufficient axioms and definitions to make the model equivalent to *any* system of *regular* polygons. By doing so, the number of members of set S might increase as they decreased in length. So, would it be possible to derive a theorem giving the ratio " p" (the ration of the circumference of a circle to its diameter) ?

A more elaborate axiomatic system, like Euclidean geometry, will usually have more definitions, more rules of deduction, and more axioms. Devising such systems is an exacting task, particularly when (as in Russell's *Principia Mathematica*) special symbols and a special syntax governing their use are required. Axioms require very careful formulation - even Russell at first provided five axioms as the basis of his axiomatic system of arithmetic, not realising that one of them was superfluous, since it was derivable from the others.

Use is however increasingly being made of such systems, and so it is important to the student to have some understanding of them and their relation to the status of the sciences. Indeed it is important to realise that "the most advanced sciences are those which most nearly approximate to the form of a deductive system. These are the sciences which have achieved a relatively small number of very general principles from which a relatively large number of other laws and special cases may be derived"[1]. Parts of physics have actually been so derived, as have parts of economics, of biology and (with less success) parts of psychology.

The simplified axiomatic example of the triangle, given above, is so simplified as to make very little deducible from it, as it stands. A better example is a Euclidean theorem, such as 'if a straight line stands on another straight line, the sum of the adjacent lines so formed is equal to two right angles". This is easily proved by drawing a line vertical to a straight line, thus making two right angles, and thus any third line to the same angular point will create 3 angles equal to two right angles. All this may thus be deduced from the definitions of angles, straight lines and perpendicularity, and the axiom that "things equal to the same thing are equal to one another". But the proof assumes certain unproved properties of parallel lines. One important rule of procedure (syntax) is that no axiom may be

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[1]See Copi (1973) *Symbolic Logic*, 4th Edn, Ch 6 *passim* - esp p. 154.

compare the economist's definition of 'price elasticity' or 'indifference' with the psychologist's definition of 'motive'.

APPENDIX G

THE ONLY DISTURBING FEATURE...

by

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... Clause analysis was generally well done by those who attempted it.. The only disturbing feature was that students who obtained high marks for analysis sometimes displayed, in their essays or précis, inability to construct a correct sentence.... (from the Examiners' Report on the General Certificate of Education, 'O' level, Summer 1962).

In *The Reader over your Shoulder*, a horrible but fascinating book with the same sort of attraction as the *News of the World* (it is strewn with the corpses of writers) the authors, Graves and Hodge, list twenty-five categories in which they tabulate the principles of clear statement. They then criticise, by applying these principles, passages from the work of such writers as T. S. Eliot, Dr. Leavis, Eric Partridge, Sir Arthur Eddington, C. Day Lewis, and Helen Waddell, and it is distressing to find that twenty lines from any of (a) them will usually produce twenty errors. Yet these are not grammatical errors in the sense given to this term by our school texts. They are more serious. They are errors in the expression of thought, possibly in thought itself. I think we may assume that all the writers quoted by Graves and Hodge are well versed in English grammar. Do we in teaching English pay too much attention to our pupils' ignorance of grammar, and too little to their errors of thought which may be at least as numerous, and more gross, than those noted in *The Reader over your Shoulder*?

The English grammar that we teach in more or less adulterated form, the grammar of Nesfield and Sonnenschein, has for years been regarded with scepticism by some linguists and teachers. The objections to it are both pedagogic and academic. It has been said, for example, that the syllabus includes too much material, presented often in such a way that the important (b) and unimportant points are undifferentiated. Only the brightest children manage to learn it, and then not safely—the 1962 Examiners' Report mentions that less than half the candidates recognised that 'sincere' was an adjective. Transfer between knowledge of formal grammar and other skills, or correlation between it and other branches of English, is very slight. The traditional terminology is not a grammar of modern English, for it is still closely tied to Latin formulations, and ignores such important signals of structure as intonation and stress and the other apparatus of spoken idiomatic English. Its use of very detailed classifications distracts the student's attention from the larger contextual units; and the details are often illogical, imprecise, and arbitrary, with criteria not consistently applied, as when we see nouns and verbs defined semantically, but prepositions functionally. Formal grammar as we know it in class is thus isolated from life and from language behaviour, and from language skills also. Evidence on such points is readily available. Discussion of the linguistic objections to formal grammar, and of the possible forms of a more accurate English grammar, may be found in the writings of Fries, Quirk, Strang, Mittins, and Gurrey; and good summaries of the evidence for the pedagogic objections exist in the Encyclopaedia of Educational Research, in Lyman, and in other work mentioned below. In view of the weight and the long standing of these objections to traditional grammar, and of the accessibility of the evidence, it is surprising that conscientious teachers should continue to use its material in the classroom.

However, it is difficult to believe, and as difficult again to admit, that a course of action that one has followed for a long time has in reality been largely mistaken, and this difficulty may account for the continued presence of instruction in an extensive grammatical terminology in the English syllabus at most schools. Whether this terminology is taught parrot-fashion, purely formally, or as what is called 'functional' grammar makes, I believe, very little difference to the amount of time wasted. What is certain is that most text-books establish only the weakest links between their terms of grammar and the practical business of writing one's native language. (d)

With these considerations in mind, practising teachers may value some recent evidence as to the value or otherwise of teaching English grammatical terms to children. This evidence was obtained in an enquiry into this matter as it affects the correctness of children's writing in the early years at the Secondary School.

A start was made by asking for the co-operation of a number of schools in a long-term experiment. Five were able to take part, but more were approached. In the discussion it was found that far from being a precise and clear subject, formal grammar seemed to mean different things to different people. What it means is usually the first question with which the would-be experimentalist is challenged, although it is the last he can get answered. Nevertheless, most teachers taught the names of the parts of speech, subject and predicate, and certain extensions of these, by one method or another, in the expectation of using this knowledge in correcting or improving written work.

Next, a number of essays written by children of ten and of fifteen years of age were analysed to ascertain the structural differences that existed between the work of young and of older children. Many appeared, but only those which were clear, measurable and definite were assumed to be indications of maturation, and were to serve as measuring instruments in the experiment.

The five schools were asked to run an English course for two years and for two forms as nearly parallel as possible. One form, however, had each week one lesson in formal grammar, whose terms were used in discussing written work, whereas the other form had no English grammar lesson at all. Naturally, influences existed which can obscure the effect of this distinction, and results of such an experiment can have no very precise scientific exactitude. Nevertheless, the difference between the work done by forms was large and simple, and could be expected to show an end in favour of or against formal grammar as taught in two liberal and progressive grammar schools, one equally adventurous secondary modern school, and the technical streams of two comprehensive schools. In four of the five schools, the pair of forms was taught by one teacher. All the children wrote an essay. Then for nearly two academic years they worked at their courses. Finally, they wrote another essay on the same topic as their first. The two essays were then compared, using the measuring instruments obtained from the early work of the ten and fifteen-year-old children.

The instruments were eleven in number, and were based on a count of the following scores:

(a) total correct sentences
(b) average number of words to each common error
(c) number of different sentence patterns
(d) number of subordinate clauses
(e) number of correct complex sentences
(f) instances of the omission of the full stop
(g) number of simple sentences with two or more modifying phrases
(h) correct non-simple minus correct simple sentences
(i) number of adjectival clauses and phrases
(j) average length of correct simple sentences
(k) total words written

Many other counts were made of the original essays, but those listed above are the clearest evidence of change. The 'common errors' used were such as the omission of a period, or of a comma in items in a list; lack of agreement between verb and subject, or failure to give a finite verb to a clause; faulty sequence of tenses; unrelated participles; the use of adjective or preposition as adverb; failure to give a pronoun a clear antecedent—all of these were more evident in the original essays. The order of reliability of the measuring instruments is that in which they are listed above. The first five are statistically very reliable; the next four are fairly reliable; the last two are not in themselves reliable, but when taken with the other nine contribute something to the general picture.

Thus there were eleven measurements in each of five schools—fifty-five in all. In the most reliable twenty-five, significantly better scores, in which the critical ratio exceeded 3.0, were made by the forms not taking grammar than by the forms taking it. The latter scored no successes of this degree. Of the less reliable measures, non-grammar forms held a significant advantage in one, grammar forms in none. The ten important scores reaching significance in a reliable measure were:

1. In the number of words per common error. Three forms, from Grammar, Technical, and Secondary Modern schools gained here.
2. In the variety of sentence patterns used. There were two gains here, in a Grammar and a Modern school; but if a level of significance of 2+ is considered, the two non-grammar forms from the Technical schools could be included.
3. In the number of correct complex sentences used. Four gains were made by the non-grammar forms, from a Grammar, a Secondary Modern, and the two Technical schools.
4. In the total number of correct sentences written. Here, one Technical school scored, and if the 2+ level of significance is included, a Grammar and a Technical school in addition.

The other significant gain by a non-grammar form was in the total words written, the form being from a grammar school. Both non-grammar forms from grammar schools gained here if the 2+ level is included. (c)

These gains by the non-grammar forms cover a wide field. Mechanical, conventional correctness—as in the number of words per common error; maturity of style—as in the variety of sentence patterns used; the control of complex relationships—as in the number of correct complex sentences; as well as general overall correctness, seen in the total number of correct sentences, were all improved significantly in groups practising direct writing skills as compared with groups studying formal grammar. It should be noted also that the gains were made in all three types of school.

Further evidence for the inadequacy of grammatical instruction to produce advantageous changes was found in scores made by all pupils in the count of individual errors of common occurrence. The five commonest errors—omission of the full stop; faulty use or omission of the comma in lists, apposition and non-defining clauses; lack of a clear antecedent for pronouns; misuse of prepositions or conjunctions; lack of a finite verb in a sentence—yielded twenty-five comparisons. Of these, twenty showed an advantage to

e non-grammar forms, of which five were significant, with a t. ratio ex-
eding 3.0. No significant gains were made by the grammar forms. And
et the non-grammar pupils might have been expected to make more mis-
kes than did the grammar pupils, for they wrote more clauses, wrote at
eater total length, and used more sentences even than the top third of the
ammar pupils.

It seems safe to infer that the study of English grammatical terminology
ad a negligible or even a relatively harmful effect upon the correctness of
ildren's writing in the early part of the five secondary schools. That sig-
ficant gains were made by forms not studying grammar need occasion
ery little surprise when one considers that an extra writing period in place
of grammar must almost double the time given each week to actual written
work in class, despite the theoretical—and highly dubitable—economy in
orrection afforded by the teacher's use of grammatical terms.

(e)

Previous experimental evidence has shown that traditional grammar is
nteachable to the point of serious application, certainly to all but the clever-
st children. It has been clearly established that there is no greater correlation
between grammatical knowledge and English skills than between two totally
unrelated subjects—indeed, correlations between say Arithmetic and Gram-
mar are often higher than those between grammar and composition. Modern
inguists have cast serious doubt upon the logical coherence and descriptive
ccuracy of the traditional terms. And finally, the work just described tends
to show that grammar gives no direct aid to children's writing skills.

Have we in fact been wasting a quarter to a fifth of our English teaching
time, and are we still doing so? If the value of grammar as an instrument in
helping children to write correctly is abandoned, is the rest worth while?
We have either to rebut the evidence, or to show that it has been misinter-
preted, or to accept its verdict. Or, of course, we can ignore it, and plead
examinations. We can escape into the comforting belief that we teach gram-
mar much more effectively than the people in all the experiments. We can
fall back on the study of grammar for its own sake—as a pure science. A
pure science (and traditional grammar may well rank as one, with astrology),
has a fascination of its own. A grammatical fact is no less worthy of dignity
than any other. We grammarians are left free to chase our definitions and
functions just for the sake of catching them, and not for food. We are sur-
rounded by a universe of facts, and we choose to remember that 'the' and
'a' always accompany nouns (with a few exceptions, of course—the fewer
the better). This, as between consenting adults, is no harm—but are we right
to teach these things to children? Choose, as the examiners sternly say, and
justify your choice!

I would add just one point for the consideration of those teachers who feel that in the upper forms of a school, at least, formal analysis should have a clearer influence for good. This sentiment may be founded in the idea that until the stage is reached at which pupils can through clause-analysis be conscious of the grammatical structure of complex sentences, little apparent relationship can be expected between knowledge of grammar and written correctness. To test this possibility, the writer took about seven hundred G.C.E. 'O'-level scripts, in 285 of which the candidates had attempted the clause-analysis question. On the whole, the answers to this question were well done. Scores made were correlated with those made by the same candidates on a combination of the other three questions—essay, précis, and comprehension. The correlation ($r = + 0.365 +/- 0.022$) suggested that there was only a weak tie between success or failure in analysis and in the rest of the paper.

The sixth form, after all, seems the most profitable place to study grammar—to argue about our present inheritance, or even better, about the new description of the actual structure of our language which surely we school teachers live in hope of receiving from the universities in the not-too-distant future. The only disturbing feature is that at sixth-form level we cease to study grammar.

Teachers interested or whose conscience is stirred to inquire more deeply into the other disturbing features of grammar may care to consult the following works of reference:

(a) On the unteachability of grammar: *The Difficulty of English Grammar*, W. J. Macaulay; *British Journal of Educational Psychology*, XVII, 1947, pp. 153–162; and also F. Cawley's article on same theme in Vol. 28, June 1958, pp. 174–176.

(b) For a general summary of doubts thrown by experimental work up to 1929, a most important source of information is *Summary of Investigations Relating to Grammar, Language and Composition*, R. L. Lyman; *Supplementary Educational Monographs*, No. 36, Univ. of Chicago, 1929; *Encyclopaedia of Educational Research*, Macmillan (New York), pp. 383–396, 1950 edition, article on English Language etc. by H. A. Greene.

(c) For further detail on the work discussed in this article, see *An Experimental Inquiry into the Function and Value of Formal Grammar in the Teaching of English*, R. J. Harris, Ph.D. thesis, London, 1962.

(d) On a new approach to grammar, see for example, *Modern English Structure*, B. Strang (E. Arnold).

APPENDIX H

THE WASON TEST

Statements that contain hypothetical conditions and implications often require careful CCA. Such statements usually involve the use of conditional and subjunctive statements. What such statements are intended to mean may depend on the context and the persons concerned. An example of the care needed is suggested by the following example of a test set by a cognitive psychologist (P.C.Wason) . It is an interesting example, for it illustrates how easy it is to fall into error in analysing concepts if great critical care is not exercised[1].

It is important for students to note, when considering set problems of this artificial kind, that the psychologist has some academic problem of his or her own to solve, and hopes to learn something from the response of the subject's behaviour to the stimulus of the problem posed. For this reason, the problem is not here stated in the form published by the inventor, for it seems that the inventor may not have been familiar with modal logic[2]. Here is the problem.

Four cards are laid before the subject. This is what the upper surfaces of those cards showed:

[2] [7] [E] [K]

The subject was then told that "Each of these four cards you see before you has a letter on one side, and a number on the other."

The subject was then told that his task was to select those cards, and only those cards, which needed to be turned over to decide the truth-value of the following statement:

S = IF A CARD HAS A VOWEL ON ONE SIDE, IT HAS AN EVEN NUMBER ON THE OTHER = Statement S.

Thus the ultimate task is to select from those cards the ones that will need to be turned over to decide whether the Statement S uppercase above is true or false.

(B) :Subjects were warned that the task was not easy, and that it required careful thought. But Dr Wason and others interested were surprised that around 85

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[1]Wason (1968) Reasoning about a rule *Quarterly Journal of Experimental Psychology*

[2]See Lewis & Langford 2nd Ed (1959) *Symbolic Logic*, pp.200 + and Appendix 2

percent of the first year university students who initially attempted the task were considered to have failed.

An analysis of the task, and an explanation will be attempted.

Clearly, the correct answer may include any or all the cards. So it makes sense to consider each card, one by one.

First: [2] must be selected, in case the statement S was falsified by (say) an X or Z

Second, [7] must be selected, in case the statement was falsified by (say) by an A or O

Third, [E] must be selected, in case the statement was falsified by (say) a 3 or 5;

Finally, must [K] be selected ? Here there is some difficulty. On the reverse of [K] we know there is a number, either odd or even. If it is ODD, then there is then no question of the truth value of S - it is TRUE. But it might be EVEN, in which case the truth-value of S is controversial. So it will be necessary to turn [K } over, in order to decide whether S is TRUE, FALSE or ? For the controversial value (See Appendix J)

So the answer is that all four cards have to turned over to decide the possible truth-value of the statement S. (For the indefinite case, see Appendix J)

Analysis of the Wason selection task is an instructive example of CCA. Dr Wason put forward a theory which rested on two assumptions - (a) that the subjects were not constrained by the propositional calculus of modern logic, and (b) that the subjects rather tended to be influenced by their own ideas about the grammar of conditional sentences.

§ 10: Analysis and Explanation

The above discussion of the Wason selection task is, as an explanation, by no means complete. Wason[1] himself points out that the subjects tested tended to assume that a conditional sentence can have three outcomes or truth values :

P, Q both true;

P true, Q false; and

P false, in which case the truth or falsity of is irrelevant.

This interpretation, Wason adds, is not new, but was debated by ancient Greek philosophers, but it is not consistent with the Whitehead-Russell calculus. Furthermore, logicians sometimes draw a distinction between material and "strict implication," but it is not intended to explore that here. Explanations and CCA, students should be made aware, always require careful thought, and may not

[1]In Foss Ed. (1966) *New Horizons in Psychology*, .

necessarily be completely satisfying, as will be more fully discussed in this and following chapters. The Wason test, and similar examples of CCA, may profitably be put before students to draw attention to the fundamental procedures involved in CCA.

The Wason Selection Test, as first administered, led to an apparent failure rate of 85 percent. This, as Wason realised, was because the precise implications of such expressions as 'if p then q' has been a matter of controversy among logicians for many centuries, and most students ignored or were unfamiliar with, the usual values given in the Whitehead-Russell calculus (WRPC). WRPC interprets 'if p then q' as 'material implication' and equivalent to (-p v q), as against the 'strict implication' of C.I.Lewis, which interprets 'if p then q' as equivalent to -(p. -q). The WRPC interpretation permits the deduction in accordance with its axiomatic system, of the equivalence X 'if p then q' is equivalent to 'if not q, then not p'.

Briefly, this is where the controversy arises; if we assume that equivalence X, then in the Wason test as stated, the statement S is equivalent to 'If there is NOT an even number on one side, then there is NOT a vowel on the other'. Suppose then that when [K] is turned over, there IS an even number, then the equivalence X is falsified, and so also is the original statement S.

On the other hand, we are at liberty to reject the idea of 'strict implication' and assert that the statement S merely asserts what the consequent is when the obverse is a VOWEL, and it thus leaves quite open the whether there is a vowel or consonant on the reverse of [K]. But we still have to turn [K] over, to decide which alternative interpretation to accept, in the event of the reverse being an even number. If it is odd, then it is irrelevant, either way.

There are other similar problems that puzzle students unaccustomed to the need for CCA. There is especially the matter of causation, is the difference between sufficient causes, necessary causes, and sufficient-and-necessary causes. In real life examples of causation, it is difficult to give examples of a situation in which a single event "causes" a single "effect". It is possible to demonstrate in a physics laboratory that the application of a bunsen burner to a metal rod causes expansion, but someone has to cause the experiment to be set up. In short, what we have is a plurality of events, some necessary, some sufficient, causing a plurality of effects. It may be possible to segregate all the necessary-and-sufficient causes from the causes which are necessary but *not* sufficient to produce the effect in a particular situation, and it may be useful (in clinical medicine for example) to do so. But the significant fact is that in order to have a collision between two motor cars it is necessary to have two motor cars. But not sufficient to have two motor cars, as it is (fortunately) possible to have two motor cars on the road and no collision. Again, in criminal courts, it is considered needful (as explained above) to establish "guilt" in order to impose just punishment. The "guilty" person is thus defined as the one who on the evidence it would be " beyond reasonable doubt" to regard as "not guilty". It cannot be beyond *any* doubt, for it is possible to doubt almost anything.

It is, again, particularly important in judgments involving historical events, to discriminate carefully between the necessary and sufficient cause. Was the rise of Hitler caused by the economic depression ? It may be possible to produce evidence that the election of Hitler as Führer was evidence of the rise, but it would be difficult to demonstrate that the large popular vote that established the political power of Hitler was itself the necessary-and-sufficient outcome of the economic depression of the years 1929-34.. How could it be shown that complex of events that constituted the economic depression "caused" most people to cast their votes in favour of Hitler's party ?

What it amounts to is that students find such problems difficult if they do not realise precisely what is to be explained. But this does not necessarily mean that if the problem is unsolved, it is because the knowledge or means of knowing is not available. The predecessors of Newton did not discover the Newtonian formula - but that was not because they had no telescopes - some of them may have had telescopes - but because they did not carefully and critically analyse the problem conceptually. They made no adequate poristic investigation.

APPENDIX J

COMPUTATIONAL THEORY

One of the most important aspects of Marr's work is his identification of three levels at which a cognitive system must be analysed. First, a task analysis leads to a computational theory of what the system does, and why it does it. Second, details of the algorithm and (system of) representation used to make the computations specified by the computational theory must be determined. Third, the neural implementation has to be specified - details of the machinery on which the computations are carried out. Neurophysiologists, AI researchers and cognitive psychologists all, according to Marr, tend to be guilty of ignoring the all-important level of 'computational theory.'

Marr is concerned with the problem of Vision, He says 'vision is to know what is where by looking'. Thus the problem is the process of discovering from images what is present in the world and where it is. To Marr, the specific problem of human vision is to describe how the human does that. He points out that things are not always what they seem. A coin may look elliptical from certain angles, he says,[1] but that is a special case - it is a very familiar model of a particular shape.

What is the real shape of a cloud? or a cat? These are things of no stable shape, but we recognise them when we see them. What is the mechanism involved. The following indicates how Marr thinks about the problem. It will be noted that particular care is taken to assess the complexities of the systems involved. He begins by illustrating the use of a *representation* as a formal system for making explicit certain types of information, or entity. When the representation used does convey the information the brain wants, then that representation is a *description* of that entity or information.

Marr goes further and explains that what is involved is a complex of information-processing systems, and these systems themselves need to be recognised. First, there are the three systems of representation, description and process. Marr exemplifies representation by instancing three ways numbers may be represented - Arabic, Roman and binary. (For example, the number 37 may thus be represented in Arabic numerals like this (in powers of 10) $3 \times 10^1 + 7 \times 10^0$, which becomes 37. In the binary system, 37 is represented as 100101; and in Roman 37 is represented as XXXVII. Thus a representation may be defined in terms of the rules for applying it, just as a musical symphony may be represented according to a recognised system (or formal scheme) of musical notation. Thus an appropriate 'formal scheme' may be devised to represent a given type of information, and then be described accordingly.

Marr then goes on to explain that representation and description may, with the addition of the appropriate process, be used to 'capture some aspect of reality'. He exemplifies this, by explaining that this is analogous to designing a modern computer, and illustrates this by instantiating a cash register, as an information processor. It is subject to certain constraints - that is, it is required to process information in a certain way for certain purposes.

In this case, the constraints are as follows: (They happen to be the laws of arithmetical addition).

1).If you buy nothing, it should cost you nothing; and buying nothing and something should cost the same as buying just the something. (The rules for zero).

2). The order in which goods are presented to the cashier should not affect the total. (Commutativity).

3). Arranging the goods into two piles and paying for each pile separately should not affect the total amount paid. (Associativity)

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[1] See Marr (1982) *Vision*, p.31

4). If you buy an item and then return it for a refund, your total expenditure should be zero. (Inverses).

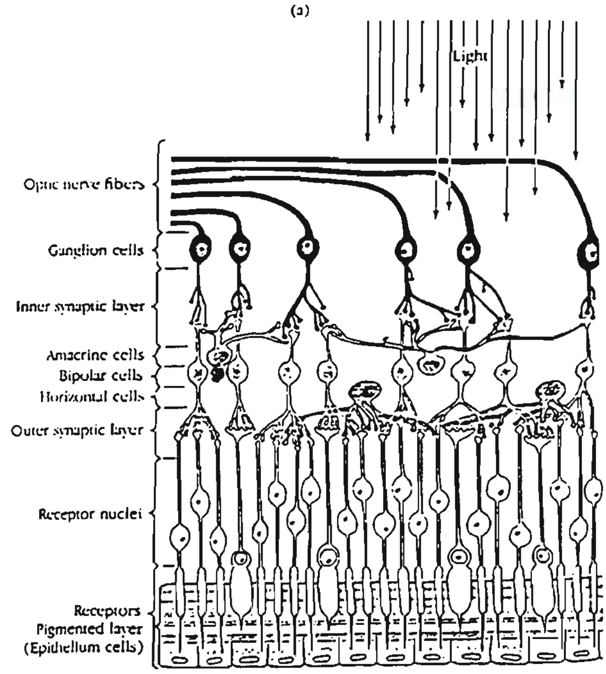
The fact that these constraints define the arithmetical operation of addition make them the appropriate computation to use. From this Marr develops his concept of computational theory. In this case, for example, it distinguishes between what is computed and why, and the resulting operation is defined uniquely by the constraints that have to be satisfied. This means that in trying, for example, to solve the problem of vision, or how humans think, there are *three* levels to be considered, a representation has first to be chosen, and an algorithm (like the laws of addition) must be chosen, and the representation and algorithm realised physically. With the cash register, both input and output will be in numbers, but this may not always be the case. In such cases the representation must be accommodated to the algorithm (as the computer deals with both binary and computer language). Of course the same algorithm may be operated with quite different languages.

Marr concludes that the solution of academic problems is thus always a complex matter requiring careful analysis of systems. He accordingly draws attention to the fact that the systems involved must not be confused, and the fact that a problem has been solved at one of the levels mentioned, does not mean that it has been solved at the others. For example, he emphasises[1] that the transformational grammar of Chomsky, like the 'systemic' grammar of Halliday, fail because of this computational limitation. While detailed discussion lies outside the scope of this study, it is pertinent to add that Winograd felt unable to criticise Chomsky's theory 'on the ground that it cannot be inverted, and so cannot be run on a computer'.

$$\nabla^2 G * I(x,y),$$

$$\text{where } \nabla^2 G(r) = -\frac{1}{\pi\sigma^4}\left(1-\frac{r^2}{2\sigma^2}\right)\exp\left(\frac{-r^2}{2\sigma^2}\right)$$

(a)



(b)

(a) The mathematical formula that describes the initial filtering of an image. ∇^2 is the Laplacian, G is a Gaussian, $I(x,y)$ represents the image, and $*$ the operation of convolution. (b) A cross section of the retina, part of whose function is to compute (a). (c) The circuit diagram of a silicon chip, built by Graham Nudd at Hughes Research Laboratories, which is capable of computing (a) at television rates.

[1]See Marr (1982) *Vision* p.28; also Winograd (1972) *Understanding Natural Language*, pp.16-28.

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GLOSSARY

The words in this glossary are given the stipulative definitions in which they are used in the context of this Dissertation and which in the absence of a stipulative meaning might cause confusion.

It is at the same time suggested that students should be encouraged to construct their own personal CCA glossaries as relevant to their studies.

This Glossary contains only words which in the experience of the compiler are likely to be unfamiliar or frequently misunderstood by many first year students when such words are used in an academic context. It does not of course contain all such words.

absolute, relative:
Absolute: standing apart and alone (eg absolute zero is -273.16 degrees C, which is not relative to any physical state like freezing). relative: considered a particular way (eg theory of relativity considers space-time relative to motion) (NB ref. of 'relative' should always be clear - 'relatively large - 'large' relative to what ?)

abstract: (abstraction, or abstract word) not to be confused with 'concept'.
A collective noun referring to the a property or class of properties or attribute of things, persons; some but not all abstractions may be concepts; eg attribute (colour, or mass) ; (eg colour is an abstract notion, and does not itself materially exist, though individual coloured objects and pigments do materially exist); mass is often. a concept (eg in Newtonian physics.

academic:
An adjective referring to those qualities associated with attempts to teach, impart information, and understand the world in which we live; such qualities as objectivity, integrity, rigour, reasoned argument and clarity of written presentation. This term is generally preferred to the term 'scientific' or 'science' which, post 19th century, tends to suggest a sometimes unquestioning and uncritical degree of certainty and unity of procedures and methods, and a false dichotomy between 'scientific facts' on the one hand, and vague notions of no value on the other.

ætiology:
The study of origins (eg embryology).

algorithm:
A procedure for giving instructions for performing complex operations by breaking down the operation into simple constituents (eg - first right, second left, third house on left); more often it is expressed as an algebraic formula; a basis for computational thinking.

entropy:
Entropy is the tendency of any closed system to move from a less probable state to a more probable state (in cybernetics); in physics applies esp. to thermodynamics

analogy, dysanalogy:
Analogy: the use in explanation of certain similarities; eg just as a parent cares for a child, so also in a colonial empire, the metropolitan country should care for its colony). As an argument this is not convincing, because there are too many relevant dysanalogies (eg colonies continue and change over many generations, and include many different families).

analysis, synthesis:
Analysis: the consideration of a whole as consisting of parts, and considering the characteristics that relate those parts, generally for purposes of explanation or problem solving, and often in terms of a particular discipline or science (eg grammatical analysis may study sentences as consisting of parts of speech; chemical analysis may consider chemicals as compounded of various elements; causal analysis may consider events as results of certain causes).Synthesis is often the complementary process of considering ways in which the analysed parts might interact to form a system, and thus cause changes of state. (eg the mould of the fungus *penicillum* was chemically analysed, the antibiotic elements identified, and then synthesised artificially to produce an antibiotic).

anecdotal:
The logical fallacy of offering a single instance as evidence in support of general hypothesis (eg; 'accountancy finals are not hard - my cousin didn't do a stroke of work and passed easily' - a useful modern addition to EAP vocabulary that deserves to survive.

artificial intelligence: (AI):
AI is a new science which studies applications of electronic computers to the solution of human and other problems.

axioms and axiomatic thinking:
All reasoned thinking involves making assumptions to begin with. There seem to be some that are what Euclid and Aristotle thought of as indispensable - such as "things that are equal to the same things are equal to ane another." Introduction of such assumptions does not reduce the persuasive power of an argument provided certain procedures are observed. These procedures vary according to the academic discipline involved, and it is important that students should understand the procedures that are regarded as acceptable to the content of their specific studies. It has been possible to discuss these procedures only to a limited case of the axiomatic set theory of Euclid as developed by modern logicians (like Whitehead and Russell) to produce the most powerful system of logic since Aristotle. But generally speaking, modern teachers often seem unaware of its relevance to particular studies, despite its obvious relevant systems analysis and computational reasoning. the gap remains to be filled.

belief:

1. Concept, which we stipulatively define as any term or phrase or symbols used to explain or partly explain a system. (example, gravitation). If a concept does not at least partly explain any system it is not a concept).

2. System: a system is set of interacting elements which interact to produce a change in state of that system. (example, the solar system of the sun, moon, and planets.) If a the elements in a system do not interact to produce a change in state, then it is not a system.

3. Critical conceptual analysis (CCA).: the process of identifying the elements in a system, and indicate how they interact, by means critical investigation of the nature of interactions between the elements system. Thus, as will be explained in due course, CCA is the decision procedure for the validity of concept., for if the concept is valid, predictions may be made. for example, Newton's algorithm about gravitation does really enable predictions to be made about the orbits of the planets.

4. A belief is particularly difficult to define, even stipulatively. It is therefore proposed to define it provisionally as any statement in the form "I believe that X" where X is any statement that may be true or false, that is, such X statements may be preceded by this provisional meaning may later be specifically modified in the interests of logical consistency and clarity. (As an indication of possibilities to come, the word 'belief' may also be replaced by words like opine, assert, affirm, hope, expect, hypothesise, guess, bet, remark, think, or any other words that indicate an act or disposition towards the truth-value of X. It should be added that the reason for the provisional stipulation is to preserve the interdisciplinary approach. Most first-year students have a good commonsense understanding of the implication of "Is he an American?" " I believe so." They are also aware that as they progress through life, beliefs change and develop for various reasons, and that the reasons are by no means always rational, even among university teachers.

See also references to belief, Chap X.

CCA Critical Conceptual Analysis: see **Concept** and Chapter IV onwards.

concept:

In the context of **conceptual thinking** in this study, a concept is any term used to explain the structure of a system, (as 'gravitation' was used by Isaac Newton to explain the interactions of the elements of the solar system in his conceptual analysis of the solar system). Thus 'concepts' emerge in the course of 'systems analysis' as functions of a system. If a term when used as a concept fails to explain the relevant system, then further CCA of the term is needed as was the case when Descartes used the 'vortex' concept to explain the solar system. (See systems analysis, below.)

correct, incorrect: (right, wrong etc) :

Correct as a term in critical thinking indicates that a statement etc is consistent with certain rules or a certain code. (eg 'his behaviour was correct' implies that it was consistent with a certain (specified or unspecified) code. (NB for such statements to be convincing, the code or rules should be specified).Wrong, right: the use of these terms suggests that the standard is moral or ethical. (NB it is considered wrong to tell lies, and right to tell the truth. (e.g. it is not incorrect to commit murder, it is both wrong and illegal).

culture:
Culture in a broad social sense is the whole range of human action and its products (artefacts) which is socially, as opposed to genetically, transmitted. (See also education.)

cybernetics:
'The science of control and communication in man and machine'(Norbert Wiener), especially the theoretical analysis. A new science (1942).

deductive:
Deductive: inferential (eg. as he is a bachelor, I infer he is unmarried)

denotation:
Denotation: when a word (eg triangle) is used to refer to the whole class of actual things (e.g. all triangles that exist anywhere) that is the connotation of the word. The denotation of 'triangle' is the list of properties that a member of the class has that distinguishes it from anything not a triangle - ie rectilinear three-sided plane figure.

definition: See references in text.

dialectic, dialectical:
Dialectic :refers generally to the Kantian idea of objective knowledge gained by reasoning and discussion, as contrasted to analytic, which is knowledge gained from the senses; also as contrasted to the subjective conversation, which relates generally to perceived sensory appearances.

EAP:
English for Academic Purposes; a language that reflects careful and critical academic thinking, not to be confused with a particular style.

education:
In most contexts in this study, the reference is to the concept of **institutionalised education (IE):** The need for training in literacy necessarily replaced earlier family education with increasingly institutionalised education no later than the invention of the printed book; pressure of subsequent discovery and increases in knowledge has led, and continues to lead to increasing systemic complexity, and consequent relevant analysis. In the present context, IE is regarded more as an historical concept for objective consideration, and less as a subject for criticism. The historical evolution of this institutionalism from Parmenides onwards perhaps deserves closer consideration than it gets.

ellipsis, elliptical:
Obvious omission of a word or words for emphasis or conciseness (e.g. the higher, the fewer).

empathy:
Projection of one's feelings towards another (eg - an experienced nurse may have empathy for a sick animal.

empirical:
Relating to experience, to actual facts as observed by the senses; sometimes contrasted with *a priori* knowledge, which is derived by reasoning or inference.

empiricism:
The philosophy of Bacon, Locke et al. - based (in its more extreme form on assumption that the evidence of the senses is the only source of knowledge of the external world; in recent centuries perhaps the prevailing English school of philosophy. The differences between sensory experiences and the way they are perceived by the cortex, and reported in language, and what these experiences are in reality are factors of great importance to students.

endogenous, exogenous:
Endogenous coming from within a system; exogenous: coming from :outside a system.

entropy, negentropy:
Entropy is what is required to get a system from one state to a desired state (eg steam (=energy) is required to get a boiler to do work. In cybernetics, entropy is applied to the tendency of a system to move to a less probable state, which may be corrected by information, and so information = negentropy or negative entropy.
ethology:
Ethology - the behavioural study of species in terms of evolution (founded by Konrad Lorentz)

explicit, implicit:
Explicit: clearly stated in the context; implicit, not stated, but implied in the context.

explanation:
Explanation is used to justify beliefs in an academic context. Explanations arise from the need to communicate experiences (see Empirical above). For the academic student much depends on the purpose of the explanation, where the purpose is often in examinations, assessments and seminars is to satisfy the teacher by feedback that the tuition is effective.

exponential:
Exponential: in mathematics: raised to a power, squared (eg exponential curve a curve sloping sharply upward to the right).

false, true:
True means having a one-one relation relation to entities; attributes or properties referred to: false: not having that relationship - in logic, applies only to statements. Definitions of 'truth' and tests of 'true' statements are difficult, and are a major philosophical problem. (see empirical above.)

falsification (as against verification):
Important in modern philosophy of science. eg a scientific hypothesis may be falsified if an implied prediction based on that hypothesis is not fulfilled: (if it is fulfilled, then the hypothesis is said to be confirmed rather than 'verified')

figurative:
Figurative language is language that is not used in a literal sense ie 'he raised the roof' (he became angry and made a commotion). Unless it helps to clarify, it is best avoided in academic English.

folk:
Folk psychology refers to 'common sense' beliefs about the 'reasons' for human behaviour; e.g. 'human beings are fundamentally selfish' Such beliefs are not necessarily always true or false (intuitive means 'untaught').

general , special:
e.g. a special theory applies only within stated limits: a general theory is applied to all cases to which the theory refers; a special theory has a more limited application.

***Gestalt* :**
Meaning 'pattern' or state - school of psychology which in some ways challenged behaviourist psychology - maintained the whole was greater than the sum of the parts.

heuristic, heuristics:
The art or discovery of successful procedures of problem-solving eg long-multiplication arithmetic, or certain procedures in cybernetics.

holism, holistic:
Holism is the doctrine that in analysis it is important to remember in taking reduction for explanation, it is possible that something may be overlooked; that in fact the whole may be more than the sum of the parts, in ways that may not be explicable in terms of an analysis of properties and relations. Whether this is so or not depends on particular cases, so each case has to be considered on its merits.

homeostasis:
Homeostasis: refers to the disposition of some systems to return to a particular state after disturbance eg bodily blood temperature tends to be homeostatic in this sense.

in fact (see of course)

idiosyncratic:
Characteristic of a particular individual; .eg many of Piaget's terms are used in a sense that is different from current usage: 'genetic epistemology'-'genetic' in this sense may refer to development, not to genes; epistemology would usually refer to a child's knowledge or understanding, not in its usual meaning as a particular branch of academic study. Students of CCA in particular need to be made aware of such idiosyncratic usage of terms, in which a writer may use a word in a personal and peculiar sense. Piaget's concept of the phrase 'genetic epistemology' is a case in point. Piaget clearly does not intend to suggest that genes have 'epistemological' problems in the sense that the philosophers Plato and Kant had. What precisely he does mean, in the absence of specific definition, may require a detailed CCA of Piaget's written work.

inertia:
Inertia: the tendency of bodies to resist acceleration, measured as mass. It has various figurative applications.

inherent, inherited:
The two words differ in meaning - inherent refers to a disposition of an attribute etc to be transmitted from one generation to another; inherited applies to a natural thing acquired from a previous generation cf. inherited wealth, inherent characteristics of a species.

intuitive, intuition :
Non-inferential awareness of subjective facts in certain contexts.

isomorphism: see Chapter V.

jargon:
Language that may be difficult to understand because it is highly specialised, peculiar to a particular profession, trade or discipline; also difficult because of inappropriate expression. 'Jargon' is often used pejoratively.

JPSB:
Justifiable problem solving belief; there is no certainty in the academic world except within a closed axiomatic system, but there are beliefs which are justified to the extent that reasons are produced that they solve problems and make predictions. See Chapter X (the word 'justification' is not here used in the purely epistemological sense, and its philosophical implications are not discussed).

mind :
A word generally avoided in the context of this study because of the variety of philosophical and disciplinary meanings in discussions of mind, body and brain. In popular usage, the word often refers to that activity of the brain concerned with conscious educated use of concepts.
Students would perhaps do well to observe that **mind** is used in various idiosyncratic senses by various persons to refer to various parts or all or part of what is perceived as the brain to which it is in various possible ways may or may not be connected. The undefined use of the word may cause endless confusion in psychological and philosophical discussion. Even the word 'mental' is difficult. Is the adjective of mind ? are 'mental states' states of the mind - if 'states' = 'activities', are 'mental activities' physical, or not ? And what is the difference between the two ? Much of the difficulty arises because we do not in fact know enough about the structure and connectivities of the human brain, and accordingly the word is avoided in the context of this study.

modal:
(logic etc): correctly used only of certain types of proposition. (See also epistemic logic and belief.)

neuro- etc. :
Appertaining especially to the central and (sometimes) the peripheral nervous system.

noise, signal:
In informatics, any random distortion of a signal (e.g. static).

of course; in fact.
These phrases are used in accordance with current stylistic convention rather than logical rigour. *Of course* indicates *as accords with assumptions*, or *in the relevant context*; *in fact* indicates *as empirically suggested, in 'real life', actually in most cases*. For example: (see **mind** above): *Of course* psychologists study aspects of the mind as part of the brain though *in fact* we do not know precisely what the connectivities are. It is hoped that stylistic impressions will be allowed to overcome pedantic objection.

objective, subjective:
Objective - refers to a detached an impersonal contextual attitude : subjective refers to personal contextual involvement (see empirical above).

operational research (O.R):
The original approach of cybernetics, involving general systems theory (see relevant GST chapters in text. In the present context OR often refers to analysis of systems in their functional environment in order to facilitate problem-solving.

paradigm:
Pattern, model. A word, currently much used after Thomas Kuhn: The Structure of Scientific Revolutions (London, 2nd ed. 1970). This word is often used vaguely.

paradigm case:
An artificial concept used to provide an essential example of a theory. In language-teaching, a standard word to exemplify a declension (noun) or conjugation (verb) of the various forms of that word may take in relevant grammatical theory. For example, in the present study, 'Newtonian gravitation' is frequently used as a paradigm case of CCA). The word itself was used by G.E.Moore to rebut the extreme sceptical view that 'nothing is certain'. In a famous lecture he said it is absurd to make such statements. I will give you a paradigm case "I have two hands". "Here" he said, taking his hand from his pocket, "is one of them" , and here, ladies and gentlemen" he said, likewise producing the other "is the other, making two in all".

parallel, serial:
In data processing most computers act sequentially; the brain appears to act massively in parallel.

Systems analysis:
Under this heading are included a number of glossal entries widely used in the text, and duly underlined. The basic activity of all academic studies is systems analysis. All phenomena that students study are comprised of systems or systems of a system. A system is defined in this study as a number of items or elements that interact so as to produce changes of state in that or any other inter-related system. A change of state is anything observed as a changed state when it occurs in that or other inter-related systems. When sufficient is observed of the properties of the elements of a system (a process known as systems analysis) to identify the system and its elements, it may then be possible to explain the interactions of the elements, and perhaps (if concepts permit) to predict successfully events relevant to the system. This, in an academic sense, is known as academic knowledge. It also involves academic concepts, which are not as such actual elements in the system, but are necessary to complete a description of the changing system. Thus a concept

in this sense is defined as any term used in attempting an explanation of a system. (A term in this sense is any word or symbol used to explain and predict. If it fails to do so, then it is clearly a misconception. The process of identifying and formulating concepts is called in this study critical conceptual analysis (CCA). The process must be critical - it must involve identifying what elements are relevant to a particular systems analysis Thus what makes an item relevant in an academic sense is its use in an explanation in a systems analysis or in CCA. Thus, if a matter has no such relevance, it is irrelevant at least in that context. For examples of the items underlined in this paragraph, the attention of teachers especially is drawn to the highly relevant references in the text to Galileo, Newton, and Whitehead and Russell, and particularly the subsequent systems analysis of Ross Ashby.

parameter:
In Economics and Mathematics a parameter is a value or a set of values that remains constant in a particular model.

percept, perception:
A difficult and sometimes obscure concept in branches of Psychology and Philosophy.

philosophic approach:
The objective in this Dissertation has been primarily to clarify rather than confuse the attitudes of students towards their studies. It is however inevitable that many of the issues discussed in relation to Critical Conceptual Analysis raise corresponding philosophical, epistemological and logical problems. If every inlet and creek that such problems suggest are invariably explored to their sources, the voyage is in danger of losing all interest and purpose.
Academic teachers themselves are of course well aware of this danger. Instead, every effort has been made to restrict such explorations and excursions to what seems essential to an understanding of the discipline alluded to as CCA.

As suggested earlier, it might well be argued that a sound course in the discipline of modern mathematical logical and analytical logic and philosophy, ('Modern Greats') such as used to be obligatory for all honours students of philosophy, psychology and economics in the 1950s might have its advantages, it is recognised that to provide such an alternative is likely to be beyond the resources of many universities, when, outside of philosophy and mathematics departments, there is a dearth of qualified teachers, even of postgraduates.
Realities however must regrettably be confronted, and although students and their teachers are thereby deprived of an understanding of the great contribution to modern knowledge that mathematical modal and deontic logic may suggest in a computational world, it is hoped that a discipline along the lines implied by CCA may be of practical value. Useful as a study of logic and philosophy may well be, the thesis of this Dissertation, its claim to originality is to suggest a simpler and more practicable way to bridge the gap referred to in the opening chapters.
The basic difficulty confronting all teachers is always where to begin. The idea of beginning elementary arithmetic with Peano's number theory might seem to logically commendable, but surely the practical difficulties and abstract thinking and concepts involved introduce impossibilities that exclude such teaching as a practical objective from the primary school. So we compromise with multiplication and the simple basics of addition and the multiplication and in subtraction, the fiction of 'borrowing' and 'paying back'.
The point however is that the compromise leaves a gap, which must be filled sooner or later if higher academic skills of mathematics are to be achieved - and the same applies to all other higher academic skills. What is suggested in this study is

that at least in the period when there comes the transition from secondary to university education that the gap should be filled the compromise of CCA.
A further consideration is the educational necessity for specific training in CCA, as part of the compulsive process of the cultural transmission of knowledge.

plasticity:
In Biology the ability of an organism to adapt easily to changing circumstances ; the word is used in Neuroscience to refer to the ability of the brain to respond to varying kinds of data and also to capacity to compensate for internal damage.

qualitative analysis:
Refers particularly to the analysis of explanations before final submission to ensure that the whole relevant problem space and systems have been considered. Unlike qualitative *research* , which tends to be restricted to alternative means of assessing social data, qualitative analysis refers to all aspects and implications of systems analysis.

random number:
A number that is unbiased.

rational, rationalism:
In Philosophy rationalists assert that knowledge comes from reasoning. rather than from the senses; see 'empirical', 'empiricism'.

statistical, stochastical:
Statistical and stochastical, as ways of calculating probability: stochastical is pure mathematical (LaPlace) probability (eg dice, cards); statistical is applied probability takes into account what statistically happens (eg the actual deaths aged 60, not the stochastical equi-probability of dying on a particular day of the week,)

subjective:
Refers to personal contextual involvement.

system:
In the context of GST a system is not a 'thing' but a set of interacting variables, e.g. a pendulum is not a system but the *oscillation* of the pendulum is part of a system of interacting variables which the investigator seeks to determine; see Chapter VII.

systematic analysis: See CCA and Chapter X §8.

taxonomy:
The science and analytical study of methods of classification; the term 'taxonomy' is often incorrectly used to refer to the vocabulary of a particular system of taxonomy 'classification'. For example, 'differentia' is a taxonomial term in used in a certain ancient Greek taxonomy, but it is a term, not a system of classification. (The distinction is important for students of CCA.)

theory:
The relationship between theories, hypotheses and assumptions as explained in Chapter XI and XII.

validity, invalidity:
Arguments in Deductive Logic are valid or invalid according to their form, not their content.